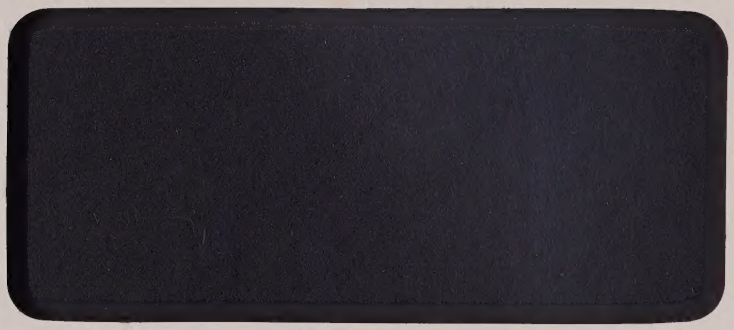
RF Tuning Head

MODEL CA-6A

INSTRUCTION MANUAL No. 110–6016

SINGER
INSTRUMENTATION



INSTRUCTION MANUAL

RF Tuning Head

MODEL CA-6A

INSTRUCTION MANUAL No. 110–6016

SINGER
INSTRUMENTATION

The Singer Company, Palo Alto Operation

3176 Porter Drive, Palo Alto, California 94304/ (415) 493-3231 TWX 910-373-1765

WARRANTY

THE SINGER COMPANY, PALO ALTO OPERATION, warrants each instrument sold by it to be free of defects in material and workmanship, effective from the date of shipment to the original purchaser for a period of 1 year except where a specific warranty period is stated in the operating manual. Microwave tubes used in standard instruments carry the best available service warranty, a copy of which is available on request.

The Seller will not be liable for incidental or consequential damages The Seller's sole liability shall be repair, replacement, or return of purchase price at our option. Warranty returns first must be authorized by the factory, and repairs or replacements (at our option) will be made without charge for instruments returned freight prepaid to the factory or authorized repair depot when our examination satisfactorily indicates that defects are due to workmanship or materials. Electron tubes, batteries, fuses, lamps and transistors are excluded from Warranty coverage. If the instrument or any portion thereof, has been abused, misused, damaged by accident or negligence, or if any serial number or seal has been removed or altered, this warranty is VOID.

This warranty is expressly in lieu of any other warranties expressed or implied, including any implied warranty of merchantability, or fitness for a particular purpose, any other obligations or liability on the part of The Singer Company, and it neither assumes nor authorizes any other person to assume for it any other liability in connection with the sale of instruments manufactured by it.

SINGER
INSTRUMENTATION

The Singer Company, Palo Alto Operation, 3176 Porter Drive, Palo Alto, California 94304
Telephone: (415) 493-3231 TWX: 910-373-1765

REPAIR AND MAINTENANCE

Instruments should be returned only on prior written authorization from the Singer Representative or the factory(1). Please provide the following information in order to expedite our processing of your instrument:

1. Model or Type
2. Serial Number
3. Approximate date instrument was placed in operation
4. Approximate number of hours of use
5. Description of trouble(2)
6. Has maintenance action been previously requested?
7. Other comments

Upon receipt of this information our Service Department will send you service data or shipping instructions. Upon receipt of shipping instructions forward the instrument prepaid to the specified center or factory. If requested, an estimate of charges will be made before work begins.

(1) West Coast Service Center, 3211 S. LaCienega Blvd., Los Angeles, California 90016, Telephone (213) 870-2761, TWX 910-340-6352 for all Singer Instrumentation equipment; or Palo Alto Operation, 3176 Porter Drive, Palo Alto, California 94304, Telephone (415) 493-3231 TWX 910-373-1765 for Palo Alto Operation instruments.

(2) Include data on symptoms, measurements taken, test instruments used, suspected location of trouble, maintenance action taken, and any other relevant data.

TABLE OF CONTENTS

Section		Page
1	INTRODUCTION	1-1
1-1	Scope of Manual	1-1
1-4	Purpose and Use of the Equipment	1-1
1-8	Optional Capabilities	1-1
1-10	Equipment Supplied with the CA-6A	1-1
1-12	Specifications	1-1
2	OPERATION	2-1
2-1	General	2 1
2-3	Installation	2-1
2-7	Controls, Indicators, and Connectors	2-1
2-9	Initial Turn-on and Adjustments	2-1
2-11	General Operating Procedures	2-4
2-12	Scanning for Signals	2-4
2-13	Obtaining Proper Resolution	2-5
2-19	Determining Spectral Component Frequencies	2-5
2-21	Graticule Amplitude Scales	2-7
2-22	Log Scale	2-7
2-23	LIN Scale	2-7
2-25	Input Signal Classification	2-7
2-28	Interpretation of Screen Presentation	2-7
2-30	Characteristics of Pulsed RF Signals	2-9
2-36	Noise Analysis	2-12
2-38	Undesirable Responses	2-13
2-43	Multiple Responses (Linear Operation)	2-13
2-47	Applications	2-14
2-48	AM Measurements	2-14
2-49	FM Measurements	2-14
2-50	Pulse Analysis	2-15
2-51	Radar Performance Checks	2-15
2-52	Antenna Patterns	2-15
2-53	RFI Measurements	2-15
3	THEORY OF OPERATION	3-1
3-1	General	3-1
3-3	Converter Circuits	3-1
3-9	Frequency Tuning	3-1
3-12	Phase Lock Stabilization	3-1
3-14	RF Input/1st Converter/1st IF	3-1
3-20	2nd Converter/2nd IF	3-2
3-24	2nd Mixer/60 MHz Pre-amplifier	3-5
3-25	60 MHz Narrow Band Filter	3-5
3-26	60 MHz IF Amplifier	3-5
3-27	3rd Converter/3rd IF	3-5
3-29	3rd Converter	3-5
3-35	2.7 MHz Narrow Band Filter	3-6
3-38	Variable Bandwidth Amplifier	3-7
3-43	Log/Lin Amplifier	3-8
3-45	Log Mode	3-8
3-49	Video Filtering	3-9
3-50	Frequency Control Circuits	3-9
3-52	Tuning Ramp Generator	3-9
3-55	Sync and Sweep Mode Selection	3-11
3-57	Sweep Synchronization	3-11
3-60	Summing/Shaping Amplifier	3-11
3-62	Phase Lock Loop	3-12
3-68	17 MHz Oscillator	3-14
3-69	17 MHz Amplifier/Harmonic Generator	3-14
3-70	Phase Lock Mixer	3-14
3-71	11.85 MHz Amplifier/Limiter	3-15
3-72	11.85 MHz Phase Detector	3-15
3-73	100 MHz Calibrator/Marker Generator	3-15
4	MAINTENANCE	4-1
4-1	Performance Tests	4-1
4-2	General	4-1
4-3	Performance Test Equipment List	4-1
4-4	Preliminary Setup Information	4-1
4-5	Center Frequency Accuracy	4-1
4-6	Scan Width Accuracy (Wideband)	4-1
4-7	Scan Width Accuracy (Narrowband)	4-2
4-8	Resolution Bandwidth	4-2
4-9	Sensitivity	4-3
4-10	Scale Accuracy (Linear)	4-3
4-11	Scale Accuracy (Log)	4-3
4-12	Image Responses	4-4
4-13	Intermodulation Distortion	4-4
4-14	100 MHz Calibrator Accuracy (Amplitude)	4-4
4-15	100 MHz Calibrator Accuracy (Frequency)	4-4
4-16	RF Attenuator	4-4
4-17	Incidental FM	4-5
4-18	Sweep Time Accuracy	4-5
4-19	Frequency Response	4-5
4-20	Residual Responses (6-1300 MHz)	4-6
4-21	Alignment Procedures	4-6
4-22	General	4-6
4-25	Alignment Test Equipment	4-6
4-26	Front Panel Assembly	4-7
4-28	Tray Assembly A1	4-7
4-30	100 MHz Calibrator A1A3	4-7
4-31	General	4-7
4-33	100 MHz Adjustment	4-7
4-34	Front Housing Assembly A2	4-7
4-36	1.44 GHz Second Local Oscillator A2A2	4-7
4-37	60 MHz IF Strip	4-8
4-38	Rear Housing Assembly A3	4-9
4-39	Log/Lin Amplifier A3A4	4-10
4-40	Third Local Oscillator A3A1 (Preliminary)	4-10
4-41	Variable Bandwidth Amplifier A3A3	4-10
4-42	2.7 MHz Narrow Band Filter A3A2	4-11
4-43	Third Local Oscillator A3A1 (Final Alignment)	4-11
4-44	Shaping Assembly/Sweep Generator A5	4-11
4-45	Phase Lock Alignment	4-12
4-46	17.0 MHz Pulled Oscillator A4	4-12
4-47	17.0 MHz Power Amplifier and Harmonic Generator A2A5	4-13
4-48	11.85 MHz Amplifier/Limiter A2A6; Detector and Reference Oscillator A2A7	4-13
4-49	Disassembly Procedures	4-13
4-50	Tray Assembly A1	4-13
4-51	Front Housing Assembly A2	4-14
4-52	Rear Housing Assembly A3	4-14
4-53	RF Attenuator AT1	4-14
4-54	17.0 MHz Pulled Oscillator A4	4-14

TABLE OF CONTENTS (CONTINUED)

Section		Page
4-55	Troubleshooting	4-14
4-56	Power Distribution Troubles	4-14
4-57	Troubleshooting Procedures	4-15
4-60	Voltage Measurements	4-15
4-62	Component Locations	4-15
5	SCHEMATICS	5-1
6	PARTS LIST	6-1
6-1	General Information	6-1
6-2	Ordering Information	6-1

LIST OF ILLUSTRATIONS

Figure		Page
1-1	CA-6A RF Tuning Head	1-0
1-2	CA-6A Controls, Indicators, and Connectors	2-2
2-2	Preliminary Display Adjustment: Markers	2-4
2-3	Preliminary Display Adjustment: 60 Hz Line Calibration	2-4
2-4	Resolution Adjustment: Effects of Controls in Display	2-6
2-5	Typical CRT Presentations of Discrete Signals	2-8
2-6	Typical Displays of Pulsed RF Signals	2-10
2-7	Effect of PRF and Analyzer Bandwidth on Pulsed Signal	2-11
2-8	Analyzer Sensitivity Correction Due to a Pulsed Signal Compared to a CW Signal at 1 kHz Bandwidth	2-12
2-9	IF Instrumentation (IM) Responses	2-13
2-10	Maximum Linear and Spurious-Free Dynamic Range as a Function of Bandwidth	2-12
2-11	Multiple Response Analysis--1.5 GHz IF	2-14
2-12	Comparison of Frequency-Base and Time-Base Displays	2-16
3-1	CA-6A Functional Block Diagram	3-3/3-4
3-2	Second LO, A2A3, Simplified Block Diagram	3-2
3-3	3rd LO/3rd Mixer Block Diagram	3-5
3-4	Narrow and Variable Bandwidth Filter/ Amplifier Function Diagram	3-6
3-5	Variable Bandwidth Amplifier Block Diagram	3-7
3-6	Bandwidth Control Equivalent Circuit	3-8
3-7	Log/Lin Amplifier Function Diagram	3-8
3-8	Frequency Control Function Diagram	3-10
3-9	Sweep Generator Function Diagram	3-10
3-10	Blanking, Retrace, and Sync Logic Block Diagram	3-11
3-11	Summing/Shaping Amplifier Simplified Diagram	3-12
3-12	Typical Diode Circuit	3-13
3-13	First LO Frequency Tuning Curve	3-13
3-14	Phase-Lock Loop Block Diagram	3-14
3-15	100 MHz Calibrator Function Diagram	3-15
4-1	Performance Test Setup No. 1	4-2
4-2	Performance Test Setup No. 2	4-4
4-3	Performance Test Setup No. 3	4-5
4-4	Performance Test Setup No. 4	4-6
4-5	Second IF Alignment Setup	4-9
4-6	Variable Bandwidth Amplifier R-C Test Network	4-10
4-7	A2A6 and A2A7 Alignment Setup	4-14
4-8	CA-6A Top View, Cover Removed	4-16
4-9	CA-6A Bottom View, Cover Removed	4-17
4-10	CA-6A Front Housing Assembly, Top View	4-18
4-11	CA-6A RF Tray, Bottom View	4-19
4-12	CA-6A LOG-LIN Amplifier	4-20
4-13	CA-6A Inside Front	4-21

LIST OF TABLES

Table		Page
1-1	CA-6A Spectrum Analyzer Specifications (Installed in MF-6A or SMF-6A Display Unit)	1-2
2-1	Control, Indicator, and Connector Descriptions	2-2
3-1	Model CA-6A Functional Assemblies	3-2
3-2	Log/Lin Diode Switch Functions	3-9
3-3	Frequency Control Functions	3-9
4-1	Symptomatic Troubleshooting Procedure	4-22
4-2	Systematic Troubleshooting Procedure	4-24
4-3	Voltage Measurements, 100 MHz Calibrator/Marker Generator A1A3	4-26
4-4	Voltage Measurements, Mixer and 60 MHz Pre-amplifier	4-26
4-5	Voltage Measurements, 1.44 GHz (Second) LO A2A2	4-26
4-6	Voltage Measurements, 60 MHz IF Amplifier A2A4	4-26
4-7	Voltage Measurements, 17.0 MHz Power Amplifier and Harmonic Generator	4-27
4-8	Voltage Measurements, 11.85 MHz Amplifier and Limiter A2A6	4-27
4-9	Voltage Measurements, Phase Lock Detector and 11.85 MHz Reference Oscillator A2A7	4-27
4-10	Voltage Measurements, Narrow Band Swept Local Oscillator A3A1	4-27
4-11	Voltage Measurements, 2.7 MHz Narrow Band Filter A3A2	4-28
4-12	Voltage Measurements, Variable Bandwidth Amplifier A3A3	4-28
4-13	Voltage Measurements, Lin/Log Amplifier A3A4	4-28
4-14	Voltage Measurements, 17.0 MHz Pulled Oscillator A4	4-29
4-15	Voltage Measurements, Shaping Assembly/ Sweep Generator A5	4-29

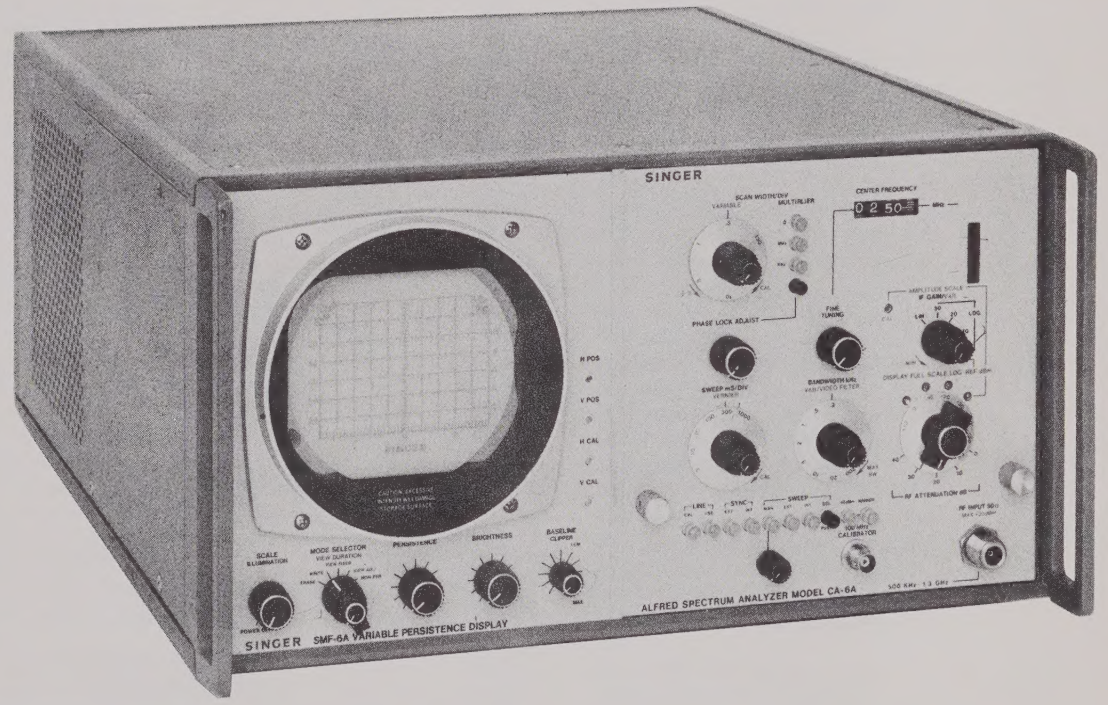


Figure 1-1. CA-6A RF Tuning Head

SECTION I

INTRODUCTION

1-1. SCOPE OF MANUAL.

1-2. This manual has general information and operating instructions for the Model CA-6A.

The CA-6A plug-in is used with either the SMF-6 or MF-6 main frame. Information relative to the main frames is in the MF-6A and SMF-6A manuals.

1-3. This manual refers to the standard CA-6A and is current to the date of publication. Available options, differences in equipment configuration, components, and performance (depending on application requirements) are described in Addendum Sheets.

1-4. PURPOSE AND USE OF THE EQUIPMENT.

1-5. The CA-6A is a wide scan, triple-conversion tuning unit, which is used with the Main Frame for visible examination of either amplitude-frequency or amplitude-time characteristics of radio frequency spectra. The CA-6A has exceptional resolving ability at any point within its frequency range of 500 kHz to 1300 MHz. Two signals of equal amplitude are easily discerned when only 300 Hz apart. Signals differing by as much as 60 dB can be resolved when only 5 kHz apart.

1-6. The CA-6A is used with either of two display Main Frames. Main Frame Model MF-6A with the CA-6A form Spectrum Analyzer SA-70A. Main Frame Model SMF-6A with the CA-6A form Spectrum Analyzer Model SA-71A. The SA-71A features variable persistence displays. Typical applications of the equipment are listed below:

a. Dynamic performance analysis of oscillators, generators and transmitters.

b. Spectrum monitoring of communications channels and radar frequencies.

c. Pulsed signals analysis.

d. Amplitude-, frequency- and pulse-modulated signal spectrum analysis.

e. Direct reading of null frequencies.

f. Microwave equipment malfunction studies (e.g., spurious-signals, instabilities, microphonics, etc.).

g. Analysis and reduction of EMI.

h. Multiplier testing and alignment.

i. Factory calibration of production RF equipment.

j. Harmonic and other out-of-band measurements.

k. Examination of CW signal drift, incidental FM and squegging.

l. Examining dynamic operating characteristics of microwave tubes and devices.

m. Checking for RF radiation and leakage.

n. Determining the presence and frequency of RF signals.

o. Use as a sensitive receiver to measure characteristics of microwave components or circuits (e.g., insertion loss and VSWR measurements).

p. Evaluation of wide range voltage-tuned oscillator characteristics.

1-7. For additional applications information, contact the Applications Engineering Department.

1-8. OPTIONAL CAPABILITIES.

1-9. The CA-6A is compatible with automated test systems and computer control. Optional programmable inputs and outputs permit control of the following CA-6A functions:

Center-Frequency Range: 0 to +12VDC input; 500 kHz to 1300 MHz range.
Scan Width: -5 to +5 V sawtooth sweeps in 1st and 3rd LO across scan width selected on front panel switch.
Scan Output: -5 V to +5 V scan-synchronized sawtooth available.
IF Bandwidth Range: +12 V selects 200 Hz to 20 kHz IF bandwidth range. -12 V provides fixed 200 kHz bandwidth.

IF Bandwidth: Adjustable with externally connected 400-500k ohm potentiometer.

Display functions: Display Mode, Brightness, Persistence, Erase.
All connections are made through a Main Frame connector.

1-10. EQUIPMENT SUPPLIED WITH THE CA-6A.

1-11. The CA-6A is normally shipped with a main frame unit and an interconnecting cable (100 MHz CALIBRATOR output to RF input). Refer to the Main Frame manual for a list of equipment normally supplied. When the CA-6A is shipped separately, an interconnecting cable is also supplied.

1-12. SPECIFICATIONS.

1-13. Table 1-1 lists electrical and physical characteristics of the CA-6A.

TABLE 1-1 CA-6A SPECTRUM ANALYZER SPECIFICATIONS (Installed in MF-6A or SMF-6A Display Unit)

FREQUENCY CHARACTERISTICS

Center-Frequency Range: 500 kHz to 1300 MHz. Display center frequency selected with digital readout control and fine tuning knob.

Center-Frequency Dial Accuracy: Within ±25 MHz. Signal frequencies may be identified to within ±0.1% with internal 100 MHz crystal markers.

Residual FM: <75 Hz peak in stabilized mode. <15 kHz peak in normal operation.

Frequency Markers: Pushbutton adds crystal markers to display every 100 MHz.

Stability With Time: ±1 kHz/min, stabilized. ±50 kHz /min, normal operation. (At fixed center frequency, after 2 hour warm-up).

Stability With Temperature: 20 PPM/°C, stabilized. 450 kHz/°C, normal operation.

Resolution: 300 Hz for two signals of equal amplitude (200 Hz bandwidth).

IF Bandwidth: 200 Hz to 200 kHz in eight calibrated bandwidths.

Video Bandwidth: Continuously variable 150 Hz to 150 kHz.

SCAN CHARACTERISTICS

Full-Scale Scan Width: Adjustable 3 kHz to 1300 MHz; pushbutton selection for wide-band or narrow-band. Scan reduced to zero in zero-scan mode.

Wide-Band Scan: 300 kHz to 130 MHz/div; six calibrated steps, with continuous control between steps.

Narrow-Band Scan: 300 Hz to 130 kHz/div; six calibrated steps, with continuous control between steps.

Zero-Scan: Operates as tuned receiver at selected center frequency.

Scan Width Accuracy: ±10% in narrow-scan mode, and all scans >10 MHz in wide-scan mode. Adjustable to ±0.1% with internal 100 MHz crystal markers.

Sweep Modes: Internal: Recurring at selected sweep rates. External: External ramp input from -5 to +5 volts for full sweep. Single: Pushbutton trigger. Manual: Manual tuning knob.

Scan Rate: 3 msec/div to 1 sec/div; six calibrated steps with continuous control between steps.

Sweep Sync: Line: Synchronized with power line frequency. Internal: Synchronized to envelope of RF signal. External: Synchronized with external trigger, +1 to +200 volts.

AMPLITUDE CHARACTERISTICS

Sensitivity (1-1300 MHz):

IF Bandwidth	S + N = 2N	Average Noise Level
200 kHz	-92 dBm	-98 dBm
20 kHz	-102 dBm	-108 dBm
2 kHz	-110 dBm	-116 dBm
200 Hz	-115 dBm	-121 dBm

Dynamic Operating Range: From -121 dBm to +20 dBm.

Amplitude Display Range: Log: 10 dB/div on 60 dB scale. Lin: Five scale divisions.

Amplitude Measurement Accuracy: Log: ±2 dB max. Lin: ±5%.

Amplitude Frequency Response: ±2 dB max., 500 kHz to 1300 MHz.

Amplitude Calibrator Output: -40 dBm ±0.25 dB from 100 MHz crystal oscillator.

RF Attenuator: 0 to 40 dB in 10 ± 1 dB steps.

IF Gain: 0 to 30 dB in 10 dB steps.

Variable IF Gain: 0 to 30 dB, continuously variable.

Signal Spurious Response: All intermodulation and harmonic distortion, image responses, out-of-band mixing responses are 60 dB (plus RF attenuation) below applied signal of -40 dBm.

Analyzer Residual Response: <-100 dBm in normal operation.

Noise Sideband: >60 dB below signal at >25 kHz away from signal with 2 kHz IF bandwidth.

INPUT CHARACTERISTICS

Impedance: 50 ohms nominal.

Connector: Type N female.

Maximum Input Level: +20 dBm.

Weight: 25 pounds

SECTION II

OPERATION

2-1. GENERAL.

2-2. The CA-6A has been factory tested and aligned and is shipped ready to operate. No attempt should be made to operate the unit until the operator is familiar with the contents of this section.

2-3. INSTALLATION.

2-4. Normally, the CA-6A is shipped installed in the associated main frame MF-6A or SMF-6A. If not, see paragraph 2-6. Unpack and check the contents of all shipping containers against the packing invoice to verify that the order is complete.

2-5. Check for damage that may have occurred during shipment. Check the controls for freedom of movement, full travel, and positive detent action. Note any mechanical damage. Check the condition of all accessories furnished.

2-6. To install the CA-6A in the main frame, proceed as follows:

a. Turn off the main frame power before installing the CA-6A. Turn the SCALE ILLUMINATION switch fully counterclockwise.

b. Be sure the 115/230 V slide switch on the rear panel main frame is set to the correct power line voltage.

c. Remove any plug-in in the main frame. Insert the CA-6A in the cavity in the main frame. Seat it firmly so the front panel is flush with the main frame front panel. If resistance is noted while inserting the module, examine the guide pins and mating connector for proper alignment or obstructions.

d. Tighten the two knurled knobs on the CA-6A to secure it in its operating position.

2-7. CONTROLS, INDICATORS, AND CONNECTORS.

2-8. Controls, indicators, and connectors of the CA-6A are described in Table 2-1 and illustrated in Figure 2-1. Associated main frame controls (MF-6A or SMF-6A) are related to the CRT display functions and are described and illustrated in the MF-6A or SMF-6A manuals.

2-9. INITIAL TURN-ON AND ADJUSTMENTS.

2-10. Use the following adjustment procedure prior to operating the analyzer. See the main frame manual for display adjustment procedures.

a. Turn on the analyzer, and allow at least 30 minutes for warm-up. Set the SCALE ILLUMINATION about mid-range. Connect the accessory cable from the 100 MHz CALIBRATOR output to the RF INPUT.

b. Set the CA-6A controls as follows:

CENTER FREQUENCY. . . . 600 MHz
CENTER FREQUENCY
FINE TUNING . . . . . Mid-range
SCAN WIDTH/DIV. 130
SCAN WIDTH/DIV
VARIABLE . . . . . Fully clockwise (CAL)
MULTIPLIER MHz . . . . . Depress
IF GAIN . . . . . LOG 0
IF GAIN/VAR . . . . . Fully clockwise (CAL)
BANDWIDTH kHz 200
BANDWIDTH kHz
VAR/VIDEO FILTER . . Fully clockwise (CAL)
SWEEP INT. . . . . Depress
SWEEP mS/DIV 3
SWEEP mS/DIV VERNIER. . Fully clockwise (CAL)
MARKER . . . . . Depress
RF ATTENUATION dB. . . . 10
All other pushbuttons . . . . Released

c. Center the 600 MHz marker at f_o on the display. Decrease the SCAN WIDTH/DIV to .3 KHz/div in steps; at each step, re-center the 600 MHz marker. Then reset the SCAN WIDTH/DIV to 130 MHz/DIV.

d. Center the 600 MHz marker at f_o with the H POS adjustment on the Main Frame.

e. Turn the CENTER FREQUENCY to about 650, and adjust it so the zero pip is at the left edge of the graticule.

f. Set the H CAL and H POS adjustments on the Main Frame so that the display shows 14 pips, with the zero pip at the left graticule edge, and the 14th pip (1300 MHz) at the right graticule edge. See Figure 2-2. Note the camera parallax.

g. Set the CA-6A controls as follows:

MARKER . . . . . Release
LINE CAL . . . . . Depress
BANDWIDTH/kHz. 2
CENTER FREQUENCY. . . . 800 MHz

h. Set the V POS and V CAL adjustments on the Main Frame to obtain the display shown in Figure 2-3.

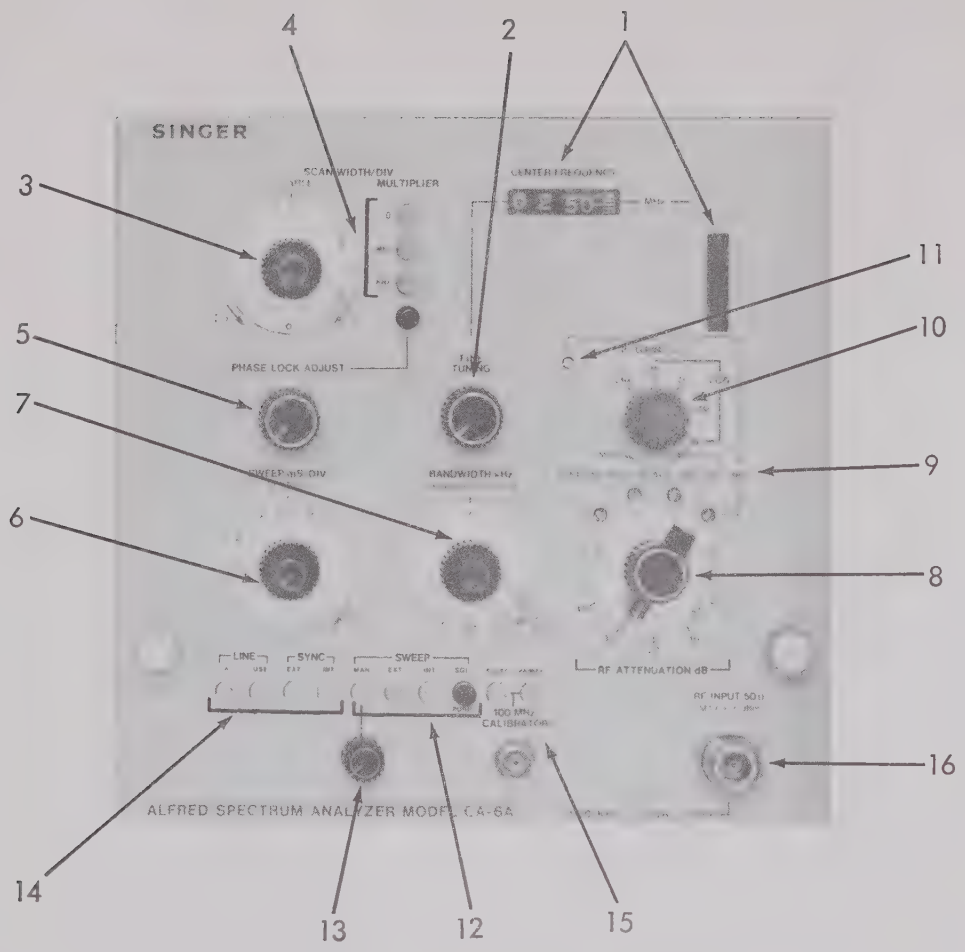


Figure 2-1. CA-6A Controls, Indicators, and Connectors

TABLE 2-1 CONTROL, INDICATOR AND CONNECTOR DESCRIPTIONS

Index No.	Function
1.	CENTER FREQUENCY: Thumbwheel control tunes the display center frequency at fo on the graticule from 500 kHz to 1300 MHz. Digital readout indicates the center frequency in MHz.
2.	CENTER FREQUENCY FINE TUNING: Tunes center frequency over narrow range; centers display on fo for narrow scan widths.
3.	SCAN WIDTH/DIV: Selects calibrated scan widths from .3 kHz to 130 MHz. Operates in conjunction with MULTIPLIER pushbuttons. VARIABLE concentric control reduces scan width continuously between steps. Scan width is calibrated when fully clockwise; divided by 3 for expanded display when fully counterclockwise.
4.	MULTIPLIER pushbuttons: Select range of SCAN WIDTH/DIV control: kHz, MHz, or zero-scan; also enables phase-lock operation in conjunction with kHz and 0 pushbuttons, 0 pushbutton: For zero-scan displays; disables swept local oscillators for fixed-frequency, time-domain display, or as a tuneable, unswept receiver. MHz pushbutton: Selects MHz SCAN WIDTH/DIV multiplier function. kHz pushbutton: Selects kHz SCAN WIDTH/DIV multiplier function. Phaselock pushbutton: Enables phase-lock circuitry that stabilizes first local oscillator for narrow scan widths, 130 kHz or less; operates in conjuction with kHz and 0 pushbuttons.

5. PHASE LOCK ADJUST: Adjusts phase-lock circuit for locking at any frequency. Operates in conjunction with MULTIPLIER pushbuttons, item 4 above.

6. SWEEP mS/DIV: Selects calibrated sweep times from 3 mS/DIV to 1 S/DIV. Concentric VERNIER provides continuous control in any range; fully clockwise is calibrated. Maximum sweep time (fully counterclockwise) with range selector at 1000 is 30 sec.

7. BANDWIDTH kHz: Selects calibrated IF bandwidths from .2 kHz to 200 kHz; in VAR position, concentric VAR bandwidth control is enabled, which permits continuous IF bandwidth adjustment from .2 to 20 kHz. Concentric VAR/VIDEO FILTER provides continuous independent video filtering (rolloff) in all bandwidth ranges, and continuous variable IF bandwidth control when selector is set to VAR. The video filter automatically tracks the VAR IF bandwidth control.

8. RF ATTENUATION dB: Selects calibrated RF input signal attenuation in 10 dB steps from 0 dB to 40 dB.

9. DISPLAY FULL SCALE LOG REF dBm: Light indicates the full-scale log amplitude reference; the light that is on indicates absolute power level at 0 or top line of graticule in dBm; indicator lights operate in conjunction with IF GAIN control.

10. IF GAIN/VAR: Selects IF gain from 0 to 30 dB in 10 dB steps for calibrated LOG display. Concentric VAR control provides continuous control in each range; calibrated gain is fully clockwise; minimum is fully counterclockwise.

11. CAL adjustment (screwdriver): Adjusts gain of second IF for calibrating the display. See Paragraph 2-9.

12. SWEEP MODE selector pushbuttons: Depress pushbutton to select sweep mode:

    INT: Sweep is free-running under control of the SWEEP mS/DIV switch.

    EXT: Sweep is controlled from an external source through rear-panel EXT HORIZ INPUT on the main frame.

    SGL: Initiates a single sweep when momentarily depressed.

    MAN: Enables manual control of CRT horizontal beam deflection by knob immediately below (13).

13. Manual sweep control: Controls horizontal deflection of CRT beam in manual sweep mode; depress MAN pushbutton to enable.

14. Sync mode pushbuttons: Depress pushbutton to select sweep synchronization/triggering.

    SYNC: INT: Sweep is triggered by the detected video signal.

    EXT: Sweep is triggered by an external signal applied to the rear-panel EXT SYNC INPUT on the main frame.

    LINE: USE: Sweep is synchronized to the power line frequency.

    CAL: CRT displays clipped 60 Hz sinewave for calibration of video circuits, and to indicate the sweep time when the SWEEP VERNIER control is not set to CAL (fully clockwise). See also Paragraph 2-9 and Figure 2-2.

15. 100 MHz CALIBRATOR: Internal crystal controlled marker/comb generator provides harmonics every 100 MHz up to 1300 MHz; connect to RF INPUT with accessory cable (supplied) from calibrator output.

    MARKER pushbutton: Depress for markers every 100 MHz.

    -40 dBm pushbutton: Depress for 100 MHz signal with absolute amplitude of -40 dBm. See Paragraph 2-9 for calibration instructions.

16. RF INPUT 50Ω: Input connector, Type N. Maximum input level is +20 dBm.

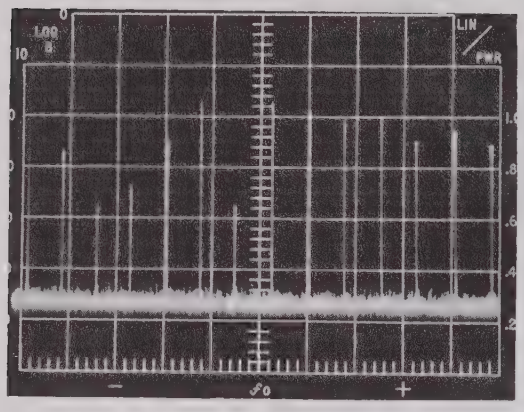


Figure 2-2. Preliminary Display Adjustment: Markers

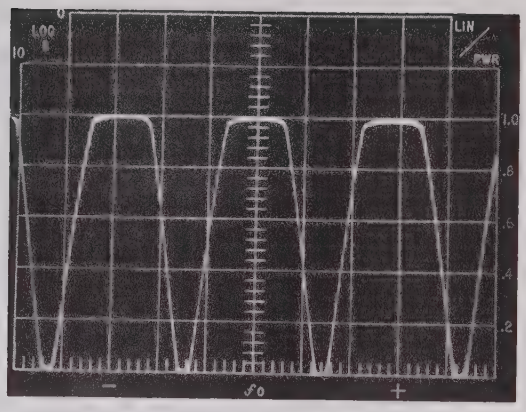


Figure 2-3. Preliminary Display Adjustment: 60 Hz Line Calibration

NOTE

The zero and 1300 MHz signals do not coincide with graticule edges due to camera parallax.

i. Set the CA-6A controls as follows:

SWEEP INT ..... Depress
IF GAIN ..... LOG 10
BANDWIDTH kHz 20
SCAN WIDTH/DIV 130
MULTIPLIER KHz ..... Depress
-40 dBm ..... Depress
RF ATTENUATION dB....0

j. Set the CENTER FREQUENCY dial to 100 MHz, or until 100 MHz CAL signal is centered in the graticule. Depress the phase lock adjust pushbutton. Adjust the PHASE LOCK ADJ until the display is locked and centered at f_o.

k. Adjust the signal amplitude with the AMPLITUDE SCALE CAL (screwdriver) adjustment so the signal displayed is full scale. The CA-6A is ready for operation.

2-11. GENERAL OPERATING PROCEDURES.

2-12. SCANNING FOR SIGNALS. To scan the input frequency range from 500 kHz to 1.3 GHz for applied signals, proceed as follows:

a. Set the CA-6A controls as indicated in Paragraph 2-10, Step b. Release the calibrator MARKER pushbutton.

b. Note the appearance of a zero pip at the extreme left of the graticule, which is local oscillator feedthrough at 1.5 GHz, and not an input signal.

CAUTION

To prevent damage to the mixer or the input attenuator, the peak RF power input must not exceed +20 dBm with 0 dB input attenuation. Similarly, with input attentuator settings of 10 to 40 dB, the peak RF power input must not exceed +30 dBm.

NOTE

The peak input power level to the 1st mixer should not exceed -30 dBm. Signals greater than -30 dBm cause distortion and spurious responses.

c. Connect the signal under analysis to the RF INPUT.

NOTE

A rise of the entire display base line indicates an applied signal at or near 1.5 GHz (see paragraph 2-46).

d. The pips appearing on the display represent the total signal content within the input frequency range. Note that the display moves to the left as the center frequency is increased. To view an individual signal component, adjust the CENTER FREQUENCY thumbwheel so that the signal of interest is centered at fo on the graticule.

2-13. OBTAINING PROPER RESOLUTION. (See Figure 2-4.) At wide scan widths, nearby signals tend to merge, and mask each other. Proper resolution depends upon two factors: the scanning velocity, which is the scan width (MHz/DIV or kHz/DIV) divided by the selected sweep time (mS/DIV); and the bandwidth of the IF amplifier stages. For a given scanning velocity, the IF bandwidth for optimum resolution is:

$$R = 1.5 \sqrt{\frac{D}{T}}$$

where

R is the bandwidth for optimum resolution (Hz).

D is the scan width (Hz).

T is the sweep time (seconds).

2-14. For optimum resolution, set the bandwidth switch to a value somewhat less than that calculated for R. The scanning velocity can be reduced by decreasing the scan width, or by decreasing the sweep speed. Reduction of the IF bandwidth improves the resolution (the ability of the analyzer to separate closely-spaced signal components). If the frequency of a low amplitude signal is close to the frequency of a higher amplitude signal, the smaller pip will be masked by the skirt of the larger pip (the amplitude-versus-frequency response of the IF circuitry being bell-shaped). As the frequency separation between the two signals increases, or the resolution of the analyzer increases, the individual signal characteristic error becomes less.

2-15. When the CRT displays a group of closely-spaced signals (such as a carrier and its sidebands) with the analyzer set for wide scans, the display may appear as a single pip. To examine the group of signals more closely, center that portion of the display at fo by adjusting the center frequency, and then setting the SCAN WIDTH/DIV switch for a narrower scan. Further improvement in the display resolution is achieved by setting the BANDWIDTH switch to VAR and adjusting the VAR/VIDEO FILTER control until best resolution is obtained. The VAR control permits continuous adjustment of the IF bandwidth from 200 Hz to 20 kHz. Narrowing the IF bandwidth for a given scanning velocity improves display resolution.

NOTE

Reducing the IF bandwidth beyond the point of optimum resolution causes a severe reduction in amplitude for CW or narrowband signals due to the limited response time of the IF amplifiers.

2-16. Another way to obtain better resolution is to increase the sweep time. The appropriate sweep time is determined by the input signal. For example, with sporadic signals, short sweep times increase the probability of intercepting the signal. For pulses, reducing the sweep time reduces the number of pulse lines per scan, if the pulse repetition frequency (PRF) is less than the analyzer IF bandwidth. However, when the PRF is greater than the IF bandwidth, the number of lines is constant regardless of the sweep time (spectral line case).

2-17. To increase the resolution capability by reduction of the frequency dispersion, narrowing the IF bandwidth, and increasing the sweep time, use the following procedure:

a. Set the BANDWIDTH kHz selector to VAR and turn the VAR/VIDEO FILTER control fully clockwise. (IF bandwidth = 20 kHz.)

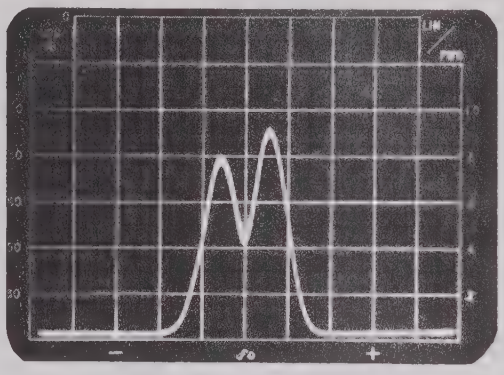
b. Set the CENTER-FREQUENCY so the desired band of signals is centered.

c. Turn the SCAN WIDTH/DIV selector counterclockwise to spread the band of signals across the screen.

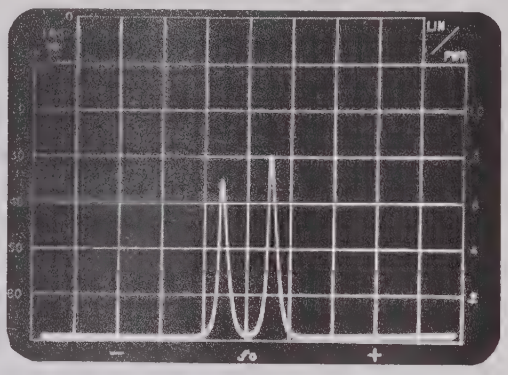
d. Rotate the VAR/VIDEO FILTER control counterclockwise until the individual signal components are clearly resolved. If optimum resolution is not achieved, rotate the VAR control fully clockwise, reduce the scan width one step, set the SWEEP mS/DIV switch to the next slower sweep time and repeat step d.

2-18. When analyzing RF pulses, it may be desirable to view the spectrum envelope rather than individual lines. If individual spectral lines are displayed, simply increase the IF bandwidth until only the envelope is displayed. To examine the noise envelope, set the BANDWIDTH kHz switch to 20 and turn the VAR/VIDEO FILTER control counterclockwise until only the noise envelope is displayed.

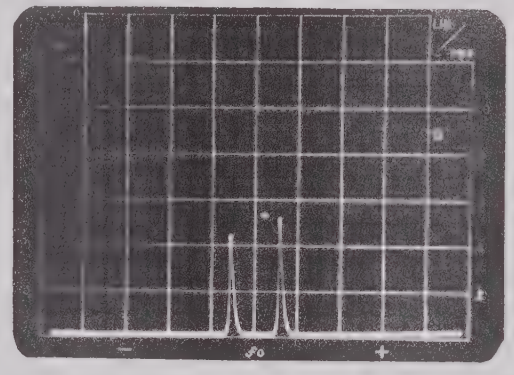
2-19. DETERMINING SPECTRAL COMPONENT FREQUENCIES. The frequency of the spectral component appearing at fo is indicated on the CENTER FREQUENCY. To determine the frequency of a spectral component appearing on either side of fo, set the SCAN WIDTH/DIV VARIABLE control fully



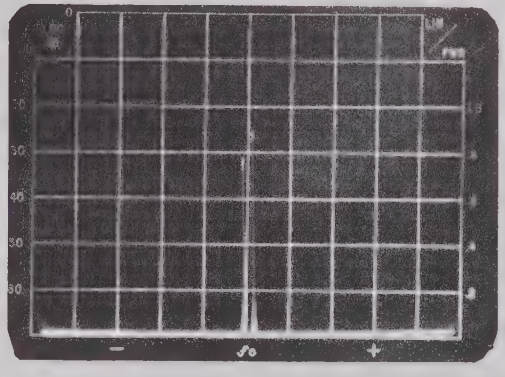
A. Bandwidth Too Broad



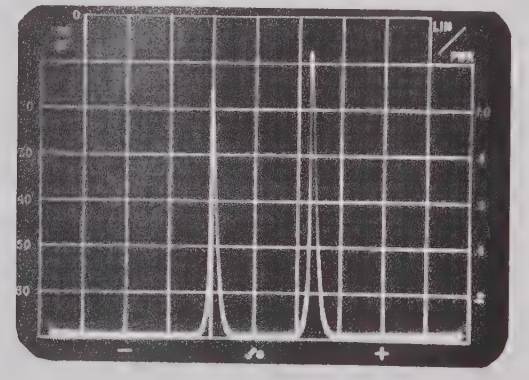
B. Optimum Bandwidth



C. Bandwidth Too Narrow



D. Two CW Signals With Excessive Frequency Dispersion



E. Same CW Signals With Proper Frequency Dispersion

Figure 2-4. Resolution Adjustment: Effect of Controls in Display

clockwise to CAL. Then note how many divisions the spectral component is from fo. Note also the calibrated SCAN WIDTH /DIV in kHz or MHz. The frequency of the spectral component equals the center frequency plus or minus the product of the selected SCAN WIDTH/DIV and horizontal displacement from fo (plus, if the component is to the right of fo; minus if to the left).

EXAMPLE: If the center frequency is 500 MHz, the scan width 10 MHz/DIV, and the component is 2 divisions to the left of fo, the component frequency is 500 MHz - 2.0 divisions X 10 MHz/DIV = 500 - 20 MHZ = 480 MHz.

2-20. To use the 100 MHz markers, connect the 100 MHz calibrator output to the RF INPUT jack along with the signal input with a T-connector, and depress the MARKER pushbutton. Markers will be at multiples of 100 MHz across the entire spectral range of the analyzer.

2-21. GRATICULE AMPLITUDE SCALES.

2-22. LOG Scale. Proper use of the 60 dB LOG scale requires that the dynamic range be equal to or greater than 60 dB. The dynamic range is limited at the low end by equipment sensitivity and at the high end by over-driving of the first mixer (typically at input levels in excess of +20 dBm). For greatest upper limit capability, there must be a minimum of losses in the IF chain. The lower limit sensitivity is determined by the setting of the BANDWIDTH kHz and IF GAIN controls. Since sensitivity is related to IF bandwidth, the optimum bandwidth should be used (see paragraph 2-13). Note that, although a 60 dB dynamic range is achieved, spurious responses may be generated.

2-23. LIN Scale. The LIN scale is used for measuring amplitude differences of signals that are within 20 dB of each other. When switching between LOG and LIN scales, the baseline may shift vertically; readjust the baseline with the Main Frame V POS adjust.

2-24. Phase Locking. With scan widths of 130 kHz/DIV, or less, the frequency sweep shifts from the first local oscillator to the third local oscillator. Incidental FM and frequency drift of the first local oscillator is virtually eliminated by the phase-lock circuit. It is continuously tunable, for locking at any frequency. To phase lock the first local oscillator, use the following procedure:

a. Set the SCAN WIDTH/DIV selector to 130, and depress the kHz MULTIPLIER pushbutton.

b. Center the display with the CENTER FREQUENCY control, and then depress the LOCK pushbutton.

c. Turn the PHASE LOCK ADJUST throughout its range until phase-lock is achieved.

d. Center the display on the graticule with the PHASE LOCK ADJUST. To tune the analyzer on narrower scans, use the FINE TUNING control.

e. To re-tune to another frequency, disable the phase-lock by releasing the LOCK pushbutton, and repeat the procedure from step a. above.

2-25. INPUT SIGNAL CLASSIFICATION.

2-26. Generally, signals to be analyzed are either discrete or non-discrete. Discrete signals are periodic waveforms having frequency components which do not vary appreciably with time. The marker generator output consists of harmonically related components, where each frequency appears as a separate marker pip on the display. Discrete signals are typical of periodic oscillation, such as modulated or unmodulated signal generators or oscillator outputs. These signals appear as line spectra.

2-27. Typically, non-discrete signals are spread over broadbands, and appear as an amplitude-varying envelope at each spectrum sample (e.g., random noise). The two amplitude scales (LOG and LIN) are equally valid for both random and discrete signals. To determine relative signal strength, discrete signals should be compared only to other discrete signals, and random signals compared to other random signals.

2-28. INTERPRETATION OF SCREEN PRESENTATIONS.

2-29. With experience, the character of each signal being displayed will be easily recognized. See Figure 2-5.

a. CW signals (see Figure 2-5A) appear as a deflection of fixed amplitude. The display width depends on the scan width, IF bandwidth, and sweep time. If the scanning velocity is not too fast, the display will be the frequency response of the IF amplifier. Deviation from a true CW signal will be recognized as follows:

(1) Oscillator drift. The display moves slowly across the screen.

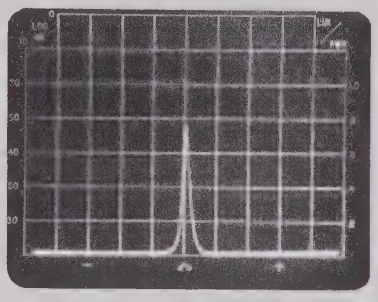
(2) Periodic drift. The display moves back and forth across the screen.

(3) Squegging (interruption of an oscillator at an audio or video rate). The display resembles a pulse modulated signal with sideband lobes on either side of the signal (Figure 2-5G).

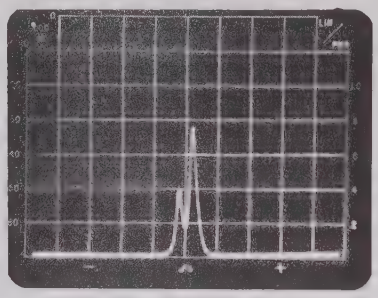
b. Two CW signals that are close enough to cause aural interference (beats) may appear as a single signal whose amplitude varies at a cyclic rate. Further separation will cause a dip at the apex of the display. By improving the resolution, the two signals will gradually separate and be easily identified (see Figure 2-5B).

c. An amplitude-modulated carrier appears as a deflection of varying amplitude when the modulating frequency is very low. Non-constant tone modulation of low frequency produces a series of convolutions varying in amplitude along the sides of the carrier pip. As the modulation frequency increases, convolutions move away from the deflection and sidebands become visible (see Figure 2-5C). It is possible to identify the sidebands by reducing the scan width and increasing the resolution.

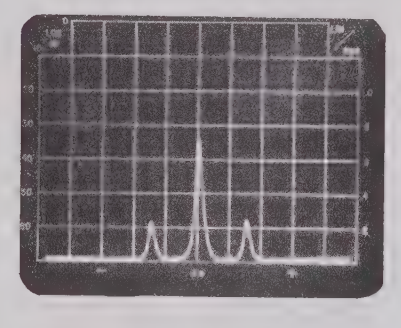
d. The appearance of single-sideband signals depends on the type of modulation. Tone-modulated signals appear



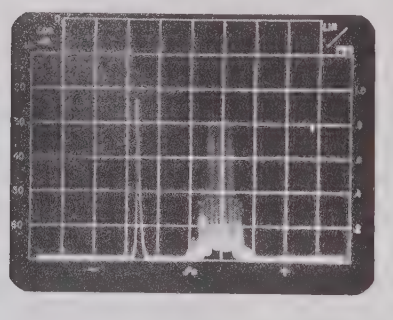
A. CW Signal



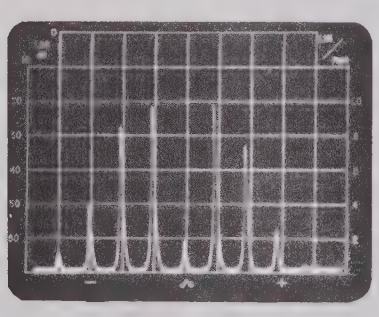
B. Two Interfering Carriers at Optimum Resolution



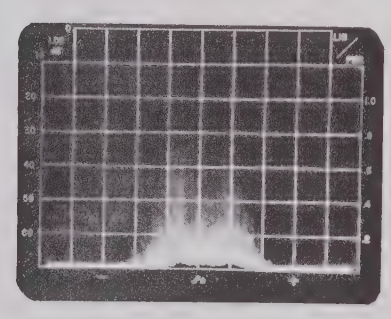
C. Single Tone Amplitude Modulated Signal



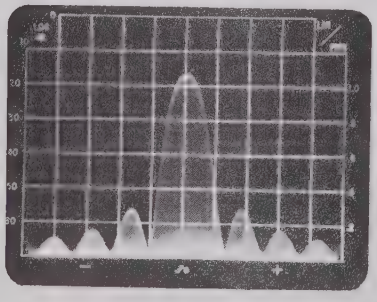
D. Single-sideband Signal Without Suppressed Carrier



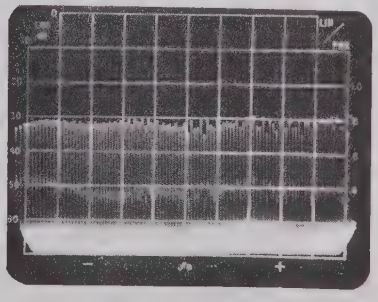
E. Frequency Modulated Signal



F. Typical Sideband Energy of Speech Modulated FM Signal (Slow Sweep Used to Display Envelope Averages)



G. Pulsed RF Signal



H. Impulse Generator Output

Figure 2-5. Typical CRT Presentations of Discrete Signals

as a carrier (for a single tone) or a series of carriers (for multi-tones) of slightly differing frequencies. Voice or music modulated single-sideband signals appear as a smear of rapidly varying signals which occupy a finite bandwidth. Figure 2-5D illustrates an amplitude-modulated single-sideband signal without carrier suppression.

e. Frequency-modulated carriers appear as a series of vertical deflections (Figure 2-5E). The spectral lines are spaced at multiples of the modulating frequency. A carrier that is frequency-modulated at a low rate appears as a carrier that wobbles sideways. The vertical deflections shift rapidly when the carrier is modulated by voice or music (Figure 2-5F).

f. A pulse-modulated signal (see Figure 2-5G) consists of a series of vertical spikes. The number of spikes depends on the pulse repetition rate, the IF bandwidth, and the sweep time. The amplitude of each spike represents the energy present at the particular frequency during one of the pulses. The spectrum envelope represents the energy distribution of the signal.

g. An impulse generator produces a train of very narrow pulses at a relatively low PRF. The spectrum consists of an extremely broad and quite flat central lobe with closely spaced spectral lines (see Figure 2-5H).

h. Various types of radio frequency interference signals may appear on the screen of the spectrum analyzer. Such signals may have either broad or narrow spectral distributions, depending on the type of interference, and may occur at constant or random repetition rates. Signals that occur at a variable repetition rate (such as those produced by accelerating motors, vibrators, buzzers, etc.) may move in either direction along the frequency axis, because the spectrum analyzer is sweeping at a fixed rate, whereas the observed signal occurs at a variable rate. These pips will be stationary on the screen when there is synchronization between the signal and the sweep. Signals produced by electrical arcing, switching transients, static and other short electrical impulses have broad spectra that may cover the entire frequency range of the spectrum analyzer.

2-30. CHARACTERISTICS OF PULSED RF SIGNALS.

2-31. Pulses that modulate the RF carrier have frequency components at the pulse repetition frequency and its harmonics. The pulsed RF signal therefore consists of the carrier frequency and sideband components spaced at the pulse repetition frequency at either side of the carrier. Thus, the greater the pulse repetition frequency, the greater the spacing between adjacent sideband spectral lines. The width of the main lobe equals twice the reciprocal of the pulse width ($2/\tau$) while both the width of each of the side lobes and the frequency difference between the carrier and the first null point is equal to the reciprocal of the pulse width ($1/\tau$). Figure 2-6A shows a perfect pulsed RF signal; the spectrum is characterized by symmetrical upper and lower sidebands and by the null points reaching the baseline. When the carrier has FM during the time of the pulse, the null points do not reach the baseline (see Figures 2-6B and 2-6C). When there is AM during the time of the pulse, the upper and lower sidebands are lower in amplitude and are spread further apart (Figure 2-6D). Figures 2-6E and 2-6F show the effect of simultaneous amplitude and frequency modulation on the spectrum of a pulsed RF signal.

2-32. The spectral lines of a repetitive pulse can be observed when the pulse repetition rate is greater than the resolution of the analyzer for the scan width and sweep rate selected. When spectral lines are to be resolved, a scan width not exceeding 100 times the PRF must be used for adequate resolution. Suitable IF bandwidths and sweep rate settings less than the PRF are also required. For typical PRF's and pulse widths, the actual spectral lines of a pulse are not resolved. In practical RF and microwave pulsed signal analysis, the envelope of the signal is of greatest interest.

2-33. Figure 2-7 shows the various displays: a given signal as a function of analyzer parameters. Accurate pulse spectrum plotting requires adequate selectivity for precise plotting of lobes and nulls. Excessive IF bandwidths smear and degrade the lobe display (Figure 2-7A). A good empirical compromise between adequate selectivity and excessive loss of pulse sensitivity due to the reduction in bandwidth is an IF bandwidth one-tenth the pulse width (see Figure 2-7C). In use, the bandwidth is set as broad as possible, consistent with an adequately sharp null definition for the lobes. The sweep rate is usually set at less than 1% of the PRF to display at least 100 pulses per scan for adequate sectional representation. A stationary spike pattern is easily obtained by using external sweep synchronization. Pulse irregularities and missing pulses can be checked in this manner. Inexperienced users of spectrum analyzers often confuse the spikes due to each pulse with actual spectral lines. A simple test to determine whether spectral lines of pulse spikes are being displayed is to observe the effect that variation of the sweep rate has on the display; if the number of vertical deflections remains unchanged, true spectral lines are being displayed (see Figure 2-7D).

2-34. An important factor to be considered in the analysis of narrow pulsed signals is the analyzer's usable pulse sensitivity. Spectrum analyzers are normally rated and specified for CW sensitivity at minimum IF bandwidth. The relationship* between CW and pulse sensitivity is:

$$e_{pulse} = \left(\frac{3}{2}\,\tau\Delta F\right) e_{CW}$$

where e_{pulse} = sensitivity to a pulsed RF signal,

e_{CW} = sensitivity to a CW signal at the same frequency,

τ = pulse width (in seconds), and

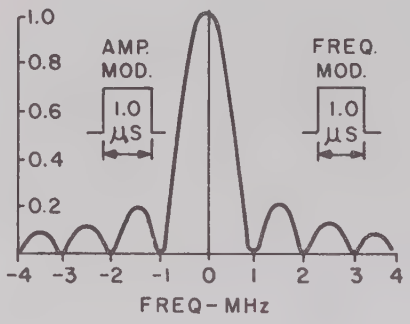
ΔF = analyzer 3-dB IF bandwidth (in Hz)

2-35. If, for example, a 0.1 microsecond pulse is applied to a spectrum analyzer whose 3 dB bandwidth is 200 kHz, then

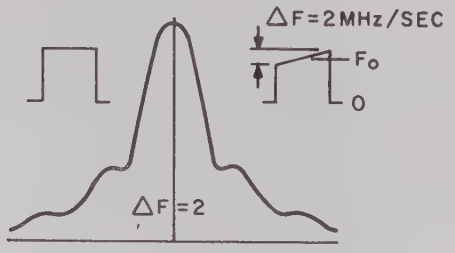
$$e_{pulse} = 1.5(0.1 \times 10^{-6})\,(200 \times 10^{3})\,e_{CW}$$
$$= 0.030\, e_{CW},$$

which corresponds to a 30 dB loss in sensitivity. This loss in sensitivity is due to the fact that the IF bandwidth required for pulse displays ($\approx 0.1/\tau$) is much greater than the IF bandwidth for CW displays, thereby the front end produces a much greater noise background. For a spectrum analyzer

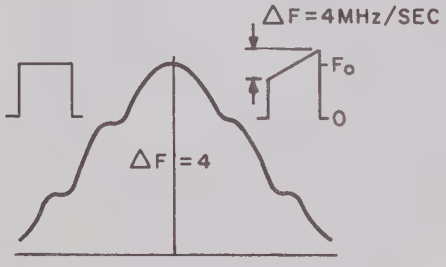
* MIT Radiation Laboratory Series, Volume XI, Chapter 7.



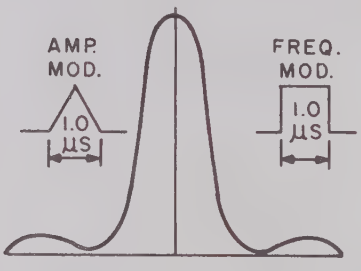
A. Spectrum of a rectangular pulse without AM or FM occurring during pulse. Shape is that of a $\frac{\sin \frac{\omega\tau}{2}}{\frac{\omega\tau}{2}}$ function.



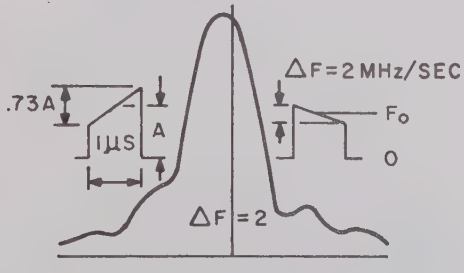
B. Spectrum of a rectangular pulse with linear FM resulting in increased sidelobe amplitude and minimums not reaching zero.



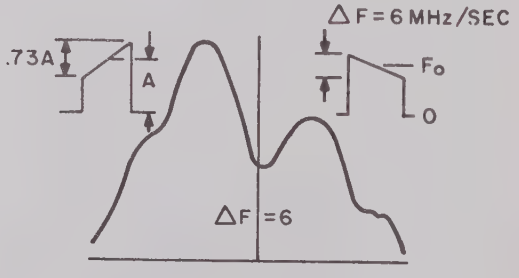
C. Same pulse as B but with more severe FM.



D. Triangular pulse spectrum without FM during pulse. Effective pulse width is shorter than A, causing minimums to occur at wider intervals of frequency and lower sideband amplitudes.

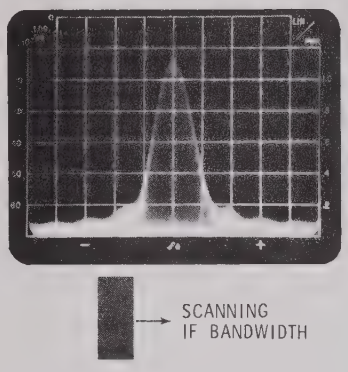


E. Effect of linear AM and FM during pulse. Observe loss in symmetry due to pulse amplitude slope.

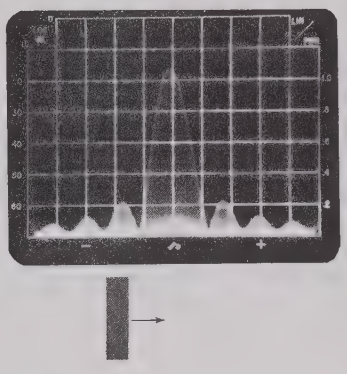


F. More severe case of FM and AM occurring during pulse.

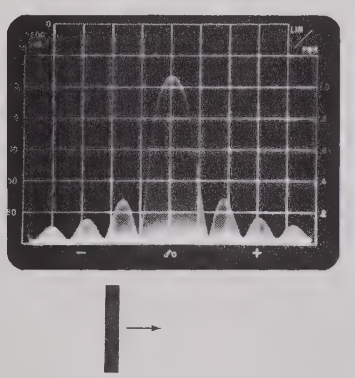
Figure 2-6. Typical Displays of Pulsed RF Signals



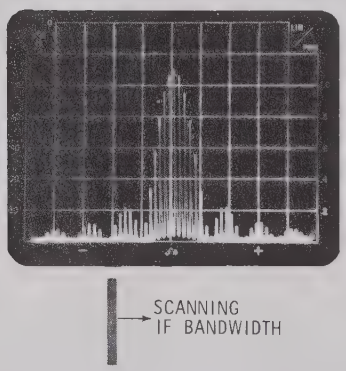
A. Extreme Case ($\Delta f_{IF} \approx 1/\tau$): Extremely wide bandwidth yields minimum information.



B. Inaccurate Envelope Case ($\Delta f_{IF} \approx 0.5/\tau$): Excessive IF bandwidth fails to resolve lobe null points and distorts envelope.



C. Accurate Envelope Case ($\Delta f_{IF} \approx 0.1/\tau$): Moderately narrow bandwidth does not resolve spectral lines but plots spectrum envelope accurately. Moderate prf.



D. Spectral Line Case ($\Delta f_{IF} < f_{prf}$): Very narrow bandwidth resolves spectral lines (within limitations of CRT beam width and visual discrimination). High prf.

Δf_{IF} = analyzer IF bandwidth (Hz)

f_{prf} = input pulse repetition rate (pps)

τ = input pulse duration (seconds)

Figure 2-7. Effect of PRF and Analyzer Bandwidth on Pulsed Signal

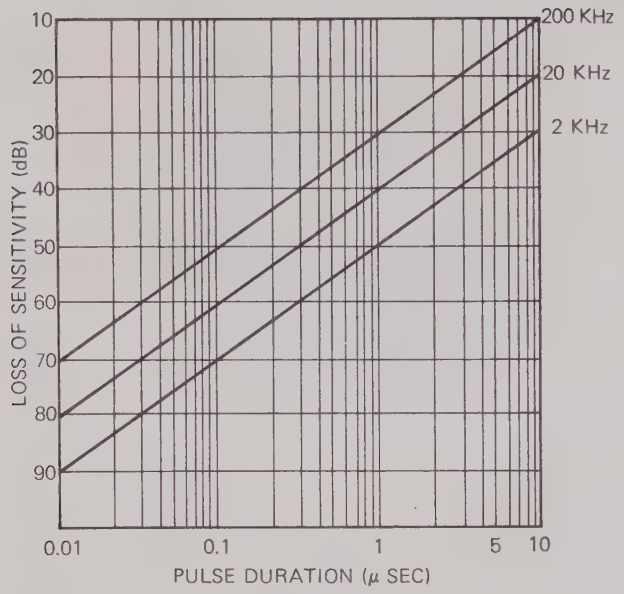


Figure 2-8. Analyzer Sensitivity Correction Due to a Pulsed Signal Compared to a CW Signal at 1 kHz Bandwidth

with a rated CW sensitivity at 2 kHz bandwidth, there would be an additional 20 dB of background noise when the bandwidth is set to 200 kHz. Thus, for the example given above, the total sensitivity difference between the deflection due to the 0.1 microsecond pulse at 200 kHz IF bandwidth and the CW signal sensitivity at 2 kHz bandwidth would be 30 + 20 = 50 dB. At a frequency where the sensitivity of the spectrum analyzer is -110 dBm and the maximum signal input level for linear operation is -30 dBm, the maximum usable dynamic range for this pulse will be 30 dB [-30 dBm - (-110 dB) - 30 dB - 20 dB]. For applications where the major lobes are of prime interest, the maximum input level can be somewhat greater without significant measurement error. A practical test of adequate freedom from non-linear operation is to check the proportionality of the change in the display following a small, calibrated amplitude change. A 10-dB attenuator in the input signal path can verify that the analyzer is not overloaded. The analyzer's sensitivity for pulsed signals is determined by adding the loss of sensitivity (a positive value) to the CW sensitivity at 1 kHz bandwidth (see Figure 2-8).

2-36. NOISE ANALYSIS.

2-37. Generally, the techniques used for discrete signal analysis are used for noise analysis, with noise defined as randomly fluctuating signals. If the input spectrum is broadband, be sure to monitor the input signal level to prevent equipment overload. The following special techniques should be noted:

a. Generally, a fairly wide IF bandwidth is preferable. It permits fairly rapid scans, with better noise envelope averaging than a narrow IF bandwidth. However, if the noise source is highly selective, an IF bandwidth that is narrow compared to the bandwidth of the resonance is required. This permits a detailed presentation of the noise characteristics. A narrow IF bandwidth requires a slow sweep rate for correct amplitude presentation.

b. Determine the proper sweep rate by changing the sweep time slightly and noting any change in the envelope amplitude. Check the portion of the envelope with the greatest slope, since the greatest change occurs there. The sweep rate should be slow enough so that a small change in the sweep rate does not result in an amplitude change. If the sweep rate is at a minimum, the scan width should be reduced and/or the IF bandwidth increased until a small change sweep rate does not change the amplitude. With the sweep slow enough for correct results, a slower sweep will improve the envelope averaging.

c. Video filtering can be used to average the noise spectrum envelope. With the BANDWIDTH kHz selector in any position except VAR, turn the VAR/VIDEO FILTER control counterclockwise until a single-line presentation is obtained.

d. The sensitivity specification (Section I) applies to discrete signals only. For absolute noise amplitude measurements, calibrate the analyzer with a noise source of known

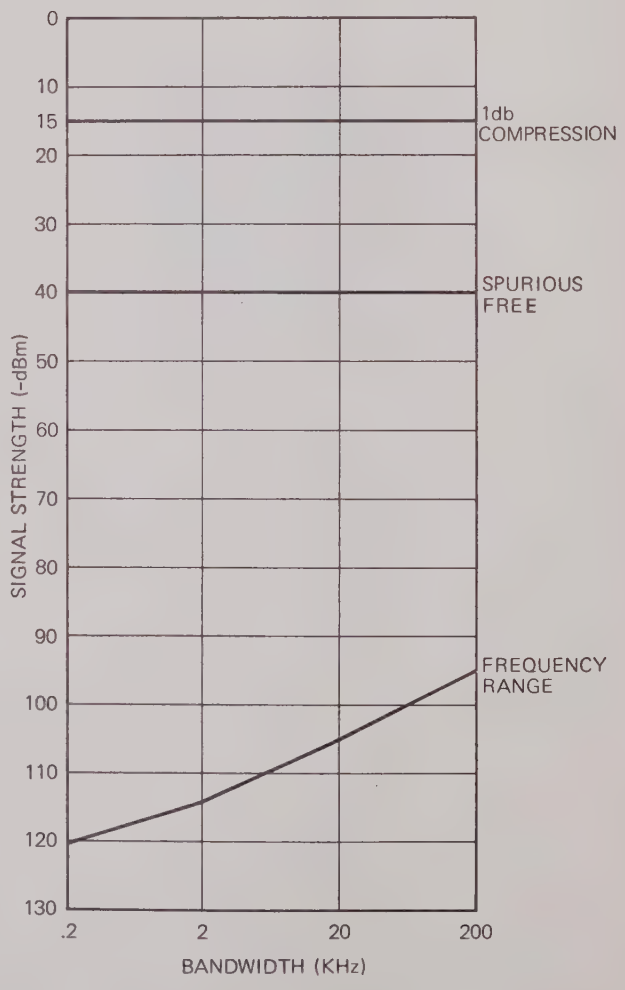


Figure 2-10. Maximum Linear and Spurious-Free Dynamic Range as a Function of Bandwidth

noise output level. Calibrate at the same scanning velocity (scan width divided by sweep time) and IF bandwidth that is used for the measurement.

2-38. UNDESIRABLE RESPONSES.

2-39. Because a spectrum analyzer has a broadband input section, undesirable responses may appear on the CRT screen.

2-40. SPURIOUS RESPONSES. There are two sources of spurious responses in any spectrum analyzer: (1) intermodulation (IM) products, which are usually generated in the IF section, and (2) first mixer spurious, which is a form of IM, caused by overdriving the first mixer.

2-41. There are two types of IM products: single-tone and two-tone. Both produce spurious responses that are mathematically related to the signal and/or local oscillator frequencies. Single-tone IM occurs when a high-level signal in the IF mixes with the harmonic of a local oscillator (Figure 2-9A). Two-tone IM occurs when two high-level signals in the IF encounter a slightly non-linear element (Figure 2-9B). In both cases the IM products are typically greater than 60 dB down when the bandwidth is 5 kHz, and the input is -40 dBm or less. Reducing the bandwidth improves the IM products at almost the same rate the sensitivity is increased, if the input signal level is similarly reduced.

2-42. High-level inputs to the first mixer may also generate IM products that are mathematically related to signal and/or local oscillator frequencies. Due to the broad bandwidth of the mixer, the relationship may be obscure. In either case, spurious responses occur at input signal levels typically greater than -30 dBm. Amplitude non-linearity will not show until signal levels are greater than -15 dBm, the point at which 1 dB signal compression occurs. Reduction of the input signal level with a corresponding improvement in sensitivity will result in a greater spurious-free dynamic range. Use Figure 2-10to determine the maximum linear dynamic range and maximum spurious-free dynamic range of the analyzer as a function of IF bandwidth. Reducing the IF bandwidth and/or sweep speed improves the dynamic range.

Example: Determine the maximum dynamic range for both linear and spurious-free operation when the CA-6A is tuned to 500 MHz and set for a bandwidth of 20 kHz.

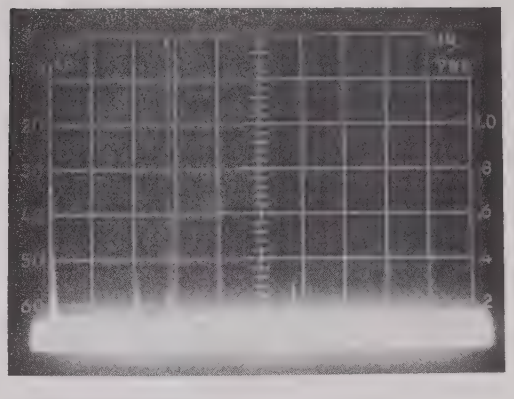
a. Note the signal strength where the 20 kHz line crosses the Freq. Range (-105 dBm).

b. Draw a vertical line through the 20 kHz point on the bandwidth axis.

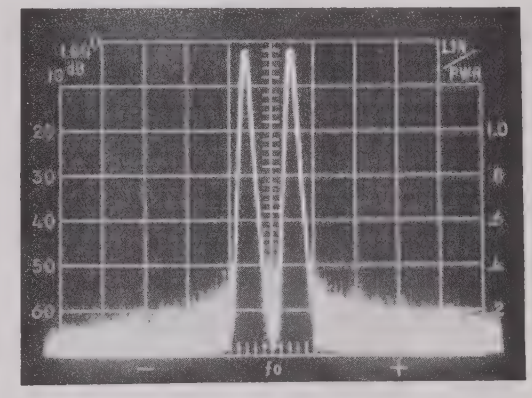
c. The maximum linear dynamic range is the difference between the 1 dB compression point (-15 dBm) and -105 dBm: 90 dB.

d. The maximum spurious-free dynamic range of the first mixer is the difference between the maximum spurious-free operating point (-40 dBm) and -105 dBm: 65 dB.

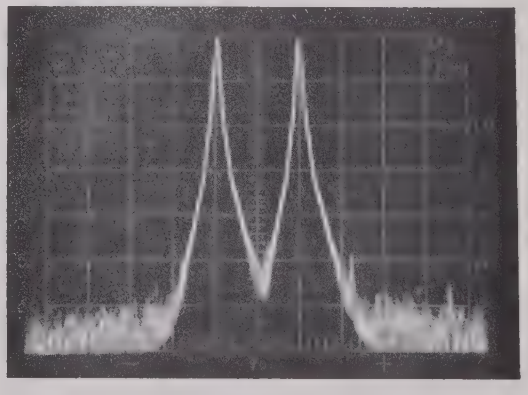
2-43. MULTIPLE RESPONSES (LINEAR) OPERATION. The CA-6A multiple response analysis chart (Figure 2-11) is a plot of input signal frequency versus local oscillator



A. Single Tone IM Products



B. Two Tone IM Products (Approximately 1300 kHz Apart)



C. Two Tone IM Products (Approximately 60 kHz Apart)

Figure 2-9. IF Instrumentation (IM) Responses

fundamental frequency which satisfy the superheterodyne conversion equation

$$f_s = nf_{LO} \pm f_{IF}$$

where

f_s = input signal frequency (GHz),

n = local oscillator harmonic employed (fundamental, second harmonic, etc.),

f_{LO} = instantaneous local oscillator fundamental frequency (variable between 1.5 and 2.8 GHz), and

f_{IF} = first intermediate frequency 1.5 GHz.

2-44. The line marked "1-" in Figure 2-11 represents the range of input signal frequencies versus the local oscillator fundamental frequency that will produce a first IF at 1.5 GHz. The "1" indicates that the local oscillator harmonic employed is the fundamental, while the superscript "-" signifies that the IF signal is derived by subtracting the input signal frequency from the local oscillator harmonic frequency. Thus, a pip representing an applied signal of .5 GHz will appear on the screen when the first LO instantaneous fundamental frequency is 2 GHz. The lines marked "2-," "3-," etc., are derived in a similar manner where the first IF of 1.5 GHz is obtained by subtracting the input signal frequency from the instantaneous first LO second harmonic, third harmonic, etc., frequency, respectively.

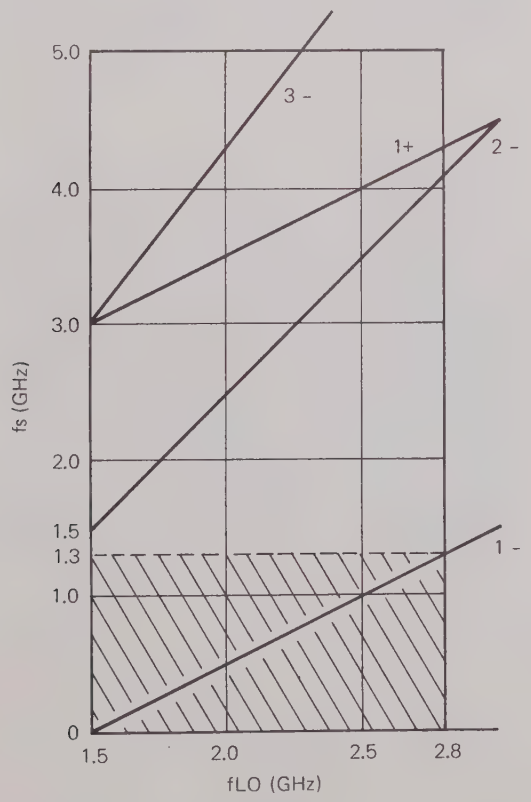


Figure 2-11. Multiple Response Analysis -- 1.5 GHz IF

2-45. The CA-6A uses only the "n-" mixing mode, so the lines marked "1+," "2+," etc. represent image responses. There are images whenever the input signal frequency equals 1 .5 GHz (the intermediate frequency) plus a harmonic of the first LO. For example, if the CA-6A is tuned to 0.5 GHz, the first LO is tuned to 2.0 GHz. The sum is:

$$1.5 + 2.0 = 3.5 \text{ GHz}$$

With a 3.5 GHz signal, a pip appears at the center of the screen. All images are twice the IF above the frequency to which the CA-6A is tuned. However, the CA-6A is spurious-free 500 kHz to 1.3 GHz. The first mixer is double-balanced and produces no even local oscillator harmonics.

2-46. From the foregoing analysis, and the fact that the CA-6A does not employ the full first local oscillator fundamental frequency range for tuning (see Figure 2-11), in-band multiple response-free displays of 1.3 GHz dispersion are obtained. There is a problem of IF freedthrough. A 1.5 GHz signal, in addition to heterodyning in the first mixer, goes directly into the first IF amplifier, causing the entire display baseline to rise.

2-47. APPLICATIONS.

2-48. AM MEASUREMENTS. To determine the percentage amplitude modulation, use the LIN scale and adjust the carrier pip amplitude for a full scale display (1 on the LIN scale). Note the relative amplitude of one sideband with respect to the carrier. Percentage modulation equals twice the ratio of sideband amplitude to carrier amplitude. Thus, if the carrier amplitude is five divisions (1.0 on the LIN scale) and the sideband amplitude is one division (0.2 on the LIN scale), percentage modulation is:

$$2 \times 0.2/1 \times 100\% = 40\%.$$

2-49. FM MEASUREMENTS. The deviation and modulation index of frequency modulated signals are easily deduced from the relative levels of the carrier and sidebands using the Bessel function coefficients of the series expansion for an FM signal (see Panoramic Analyzer, Volume I, No. 4 for FM measurement techniques). Deviations of transmitters and signal generators are measured by varying the modulation frequency until the first carrier null is obtained. The deviation is then obtained by multiplying the modulating frequency by 2.4. This is the most accurate method of measuring deviation and actual band occupancy of the sidebands. This dynamic analysis also has the advantage of the revelation of second order effects (such as residual AM) which causes assymmetrical sidebands. To determine the deviation of an FM signal generator or transmitter, proceed as follows:

a. Couple the analyzer to the unit under test. Do not exceed the maximum analyzer input level.

b. With the unit under test unmodulated, tune the analyzer to center the carrier frequency on the screen.

c. Modulate the unit under test with a suitable frequency and minimum output level. The modulation frequency should be greater than the selected analyzer bandwidth.

d. Slowly increase the modulator output amplitude until the carrier amplitude decreases to its first null. Increase the IF GAIN to maximum sensitivity to observe the null. At

the first null, the modulation index is 2.4 and the deviation is 2.4 times the frequency of the modulating frequency. Higher order carrier nulls and/or sideband nulls can be evaluated using Bessel tables.

2-50. PULSE ANALYSIS. Pulsed RF signals can be analyzed and the pulse width measured with a frequency domain display on a spectrum analyzer. Many pulse characteristics can be verified by converting to a standard oscilloscope display (amplitude vs time, or time domain). For example, pulse width incidental AM, and pulse repetition rate can be measured directly. See Figure 2-12. For a time domain display of RF pulses, first obtain a convenient frequency domain display, and then use the following procedure.

a. Set the CENTER FREQUENCY so the peak of the main lobe is at f_o on the display (Figure 2-12A).

b. Set the BANDWIDTH kHz to 200.

c. Phase-lock the display. See Paragraph 2-24.

d. Depress the 0 MULTIPLIER pushbutton.

e. Set the SWEEP mS/DIV switch as desired.

NOTE

For best results, do not change the FINE TUNING control in zero-scan mode.

2-51. RADAR PERFORMANCE CHECKS. The analyzer can be coupled (via directional couplers or an antenna) to a radar set to evaluate its operation.

a. The radar output pulse can be observed on the analyzer to determine pulse width, pulse repetition rate, incidental AM and F M, mode failures and relative sidelobe amplitude and symmetry.

b. The energy distribution in the transmitted pulse can be determined and used as the basis for receiver bandwidth design. If the receiver bandwidth is too narrow, the pulse shape is not preserved and the radar accuracy is compromised. Conversely, increasing the receiver bandwidth beyond the point of optimum energy reception serves no useful purpose and decreases the signal-to-noise ratio.

c. Receiver AFC can be checked by displaying both the magnetron output and the local oscillator frequency simultaneously. Because the magnetron is pulsed, the display will be a typical RF pulse pattern. The receiver local oscillator output, however, is a single pip displaced from the center of the pulse pattern by the IF frequency. Any magnetron pulling resulting from antenna rotation should produce a corresponding shift in local oscillator frequency.

d. TR boxes may be tuned accurately to the magnetron frequency by first tuning the analyzer so the magnetron frequency is centered on the display. Then, with the magnetron turned off and an impulse generator applied to the TR box, the analyzer will display the frequency response characteristics of the TR box, which can then be tuned so its center frequency is the same as the magnetron.

2-52. ANTENNA PATTERNS. An X-Y plot of antenna patterns can be obtained by synchronizing the analyzer sweep to the antenna rotation, and using the spectrum analyzer as an RF voltmeter.

a. With the antenna under test installed on a rotating platform, and connected to the analyzer, adjust the analyzer for a LOG display, and tune it to the transmitted frequency. Adjust the tuning controls for maximum display amplitude, phase-lock the display, and depress the 0 MULTIPLIER pushbutton.

b. Depress the SGL SWEEP pushbutton, and set the SWEEP mS/DIV switch to 1000.

c. Connect an X-Y recorder to the rear-panel VERT and HORIZ OUTPUT terminals on the main frame.

d. Rotate the antenna at a speed slightly faster than 6 RPM, so the antenna revolves once during one sweep.

e. When the antenna is directed away from the transmitting antenna, depress the SGL pushbutton. The main lobe of the antenna pattern will be approximately centered on both the CRT and recorder.

2-53. RFI MEASUREMENTS. Spectrum analyzers are useful for helping to locate and analyze signals to be measured by an RFI meter. A spectrum analyzer does not replace an RFI meter for measuring absolute signal levels. On the other hand, the very narrow window of the RFI meter makes it impractical to locate signals (scanning), and the meter indications are not as conclusive as a spectrum analyzer display for evaluating the type of signal being measured.

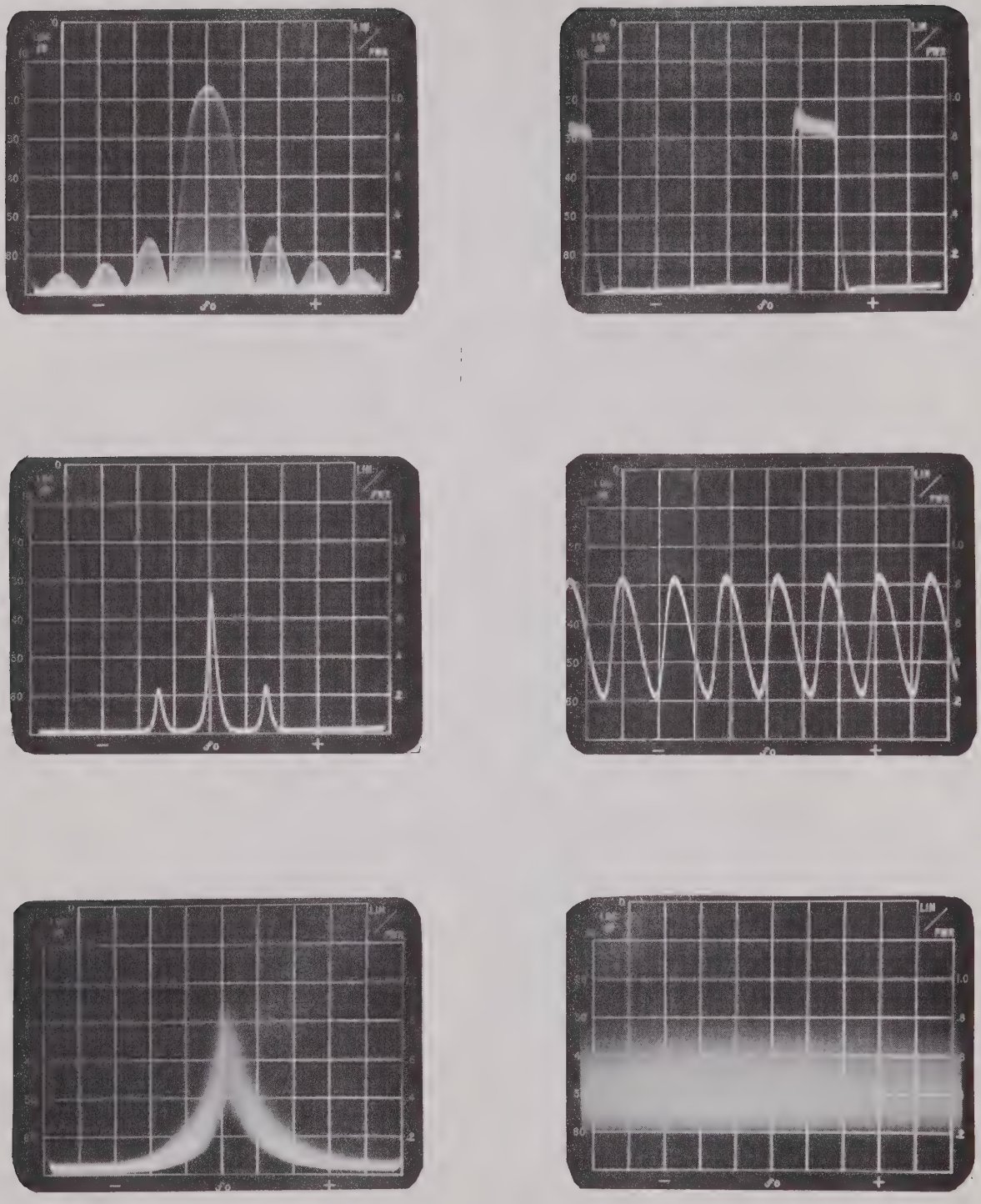


Figure 2-12. Comparison of Frequency-Base and Time-Base Displays

SECTION III
THEORY OF OPERATION

3-1. GENERAL.

3-2. The CA-6A is a wide-band, triple-conversion superheterodyne tuner that automatically sweeps across all or part of the frequency band between 500 kHz and 1300 MHz. The first intermediate frequency (IF) is at 1.5 GHz, the second IF is at 60 MHz, and the third IF is at 2.7 MHz. The third IF has both a variable bandwidth amplifier (for resolving closely spaced signals) and an amplifier that has either logarithmic or linear gain. The Log/Lin amplifier output is demodulated to detect amplitude, and then it goes to the main frame, where the signal appears as a calibrated amplitude display. The horizontal deflection of the display is synchronized with the local oscillator frequency sweep, so the vertical deflections are automatically positioned on the frequency-calibrated horizontal axis. Figure 3-1 shows the functional relationship of all major circuits.

3-3. Converter Circuits. The RF input is attenuated by a step attenuator to prevent overloading of the mixer circuits. The input signal is then mixed with the output of first local oscillator, and is up-converted to 1.5 GHz, which is the first intermediate frequency (1st IF). Up-conversion eliminates spurious responses that would occur in a low IF. Fundamental frequency mixing in all converters minimizes harmonic responses.

3-4. The first local oscillator (1st LO) is a solid-state, voltage-controlled oscillator (VCO) that is tunable from 1.5 to 2.8 GHz. For wide scans (.3 MHz/DIV, and greater) the 1st LO is tuned about the center frequency (fo) by the tuning voltage ramp from the sweep generator. The scan width is determined by the SCAN WIDTH/DIV selector, which attenuates the tuning voltage ramp. For the maximum scan, the 1st LO sweeps from 1.5 to 2.8 GHz, to cover the entire 1.3 GHz RF input range. The center frequency is adjusted by the CENTER FREQUENCY thumbwheel and indicated in MHz on the counter.

3-5. The 1st IF is filtered by a 1.5 GHz band pass filter and a 2 GHz low-pass filter to prevent spurious responses.

3-6. The 1st IF is mixed with the output from the 2nd LO (at 1.44 GHz). The difference frequency, at 60 MHz, is pre-amplified, filtered, amplified again, and then goes to the 3rd mixer. The 2nd IF amplifier gain is variable in 10 dB steps over a 30 dB range. The output of the 2nd IF goes to the 3rd mixer, where it is down-converted to the 3rd IF at 2.7 MHz.

3-7. The 3rd LO is a stable, voltage-controlled, LC oscillator that is tunable from 56.5 MHz to 38 MHz. The 3rd LO frequency is fixed for wide scans, and is swept for narrow scans. Scan width is controlled by the SCAN WIDTH/DIV selector, and the VARIABLE control.

3-8. The 3rd IF has an amplifier, a narrow band filter, and then a variable bandwidth amplifier that is controlled by the VAR (BANDWIDTH kHz) control. The output stage is the LOG/LIN AMPLIFIER. In LOG (Logarithmic) mode, gain is proportional to the log of the input signal amplitude. In LIN (Linear) mode, gain is linear.

3-9. Frequency Tuning. The sweep generator output is a 10-volt tuning voltage ramp that goes to the shaping amplifier for tuning the voltage controlled 1st LO. The same ramp drives the horizontal deflection circuits in the main frame for the frequency-calibrated horizontal display. The sweep generator also supplies a blanking pulse to shut off the beam in the CRT during retrace.

3-10. For wide frequency scans, the tuning voltage ramp from the sweep generator goes to the summing/shaping amplifier. The summing circuit adds the tuning voltage ramp and the center frequency tuning voltage; the result is a ramp that sweeps symmetrically about the center frequency voltage. The shaping amplifier compensates for the non-linear tuning characteristics of the 1st LO. The result is a negative exponential tuning voltage curve.

3-11. For narrow scans (130 kHz/DIV, and less) the 1st LO is set to a fixed frequency by the CENTER FREQUENCY control. The kHz MULTIPLIER pushbutton routes the tuning voltage ramp to the 3rd LO for the narrower scans — 300 Hz to 130 kHz. For zero scans, the tuning voltage ramp is disconnected from both local oscillators.

3-12. Phase Lock Stabilization. For zero and narrow scans, the display resolution is limited by the frequency stability of the 1st LO, which is held at a fixed frequency. To obtain low FM and drift, the 1st LO is phased-locked to a stable crystal reference oscillator. Under these conditions, the only inputs to the summing/shaping circuit are the center frequency tuning voltage and the phase-lock stabilization voltage. The phase lock circuit is inoperative for wide scans.

3-13. The phase lock loop operates by mixing the first local oscillator output frequency with one of the harmonics from the crystal oscillator that is "pulled" by the PHASE LOCK ADJUST. The difference (or IF) frequency is filtered and amplified. A phase detector compares the IF signal phase with the phase of a reference signal generated by a crystal oscillator at the same frequency. If the 1st LO frequency shifts, there will be a relative phase shift and the phase detector will have an output error voltage that goes to the summing/shaping amplifier and corrects the drift.

3-14. RF INPUT/1ST CONVERTER/1ST IF.

3-15. Fig. 5-1, the inter-assembly cabling diagram, shows the functional relationships of the major circuit components in the CA-6A. The RF input attenuator, and the majority of the components in the tray assembly (A1) are either single-component assemblies, such as the filters, mixers, and attenuator pads, or sealed functional assemblies, such as the RF attenuator, and the first local oscillator. Table 3-1 lists the functional assemblies used in the CA-6A. For maintenance purposes, all are to be considered as replaceable components.

3-16. The 1st LO operates in either of two modes: swept, or single frequency. In either mode, it is electronically tuned from 1.5 to 2.8 GHz. For single frequency operation,

TABLE 3-1. MODEL CA-6A FUNCTIONAL ASSEMBLIES

Component	Assembly Number
RF attenuator	AT1
First Mixer	A1A2
1.5 GHz bandpass filter	A1FL2
2 GHz low pass filter	A1FL3
1.44 GHz bandpass filter	A1FL4
1.3 GHz low pass filter	A1FL5
1.5 GHz high pass filter	A1FL1
Phase-lock mixer	A1A4
First Local Oscillator	A1A1
10 dB Attenuator	A1AT1
3 dB Attenuator	A1AT2

The above components are all mounted on the tray assembly, with the exception of the RF attenuator, which is mounted on the front panel assembly.

the 1st LO operates with or without phase-lock stabilization. The frequency is determined by the sum of the center frequency control voltage and the phase lock loop error voltage (if any).

The fixed frequency mode is normally used for narrow frequency scans, at which time the 3rd LO is swept. In the swept mode, the 1st LO is tuned across the full frequency range, or any part. The minimum calibrated sweep width is 3 MHz. For swept operation, the frequency of the 1st LO is determined by the sum of the center frequency tuning voltage and the sweep or tuning voltage ramp.

3-17. The output power of the 1st LO is +17 dBm minimum. The primary output goes to a 10 dB pad (A1AT1), and then to the first mixer. The 10 dB pad provides isolation between the LO and the first mixer. The secondary output from the 1st LO (from output 2) goes to the phase lock mixer.

3-18. The first mixer is a double-balanced unit with fairly flat wide-band response. The mixer up-converts the input signal to the first intermediate frequency (IF) at 1.5 GHz. The IF is filtered by a 1.5 GHz bandpass filter and a 2 GHz lowpass filter, in that order.

3-19. The filtered 1st IF goes through a T-connector (TNC) to the second mixer, which is part of the front housing assembly (A2). The other input to the T-connector is from the 2nd LO at 1.44 GHz.

3-20. 2ND CONVERTER/2ND IF.

3-21. 1.44 GHz 2nd LO. The 2nd LO is an oscillator-buffer-doubler chain that drives a 240 MHz harmonic generator. Harmonics extend to at least 4 GHz.

3-22. Q1 is a conventional, 120 MHz crystal oscillator. See Figures 3-2 and 5-4. Y1 controls the frequency, and C3 tunes the oscillator tank circuit. Q2 is a transformer-coupled buffer amplifier. Its output drives T-Network R8 through R10, to limit the drive and match the input impedance of frequency doubler Q3. L3 and C8 through C11 filter spurious signals for a clean 120 MHz signal. Doubler Q3 has both series and parallel tuning to attenuate all except the 2nd harmonic at 240 MHz. C14 and 15 are tuning capacitors. Q4 amplifies the 240 MHz signal for sufficient power to drive the comb (harmonic) generator. C21 and L12 are series tuned for 240 MHz at maximum output power; R14 establishes the output impedance at about 30 Ohms. Other harmonic responses are shunted to ground through L14 and C22. L15-L16 and C23-C24 are tuned to maximize the signal power applied to step recovery diode CR1, which generates harmonics when it is overdriven. The output from CR1 is a harmonic frequency comb that extends from 240 MHz to at least the 17th harmonic at 4.08 GHz. R15 through R17 match the LO output to the 1.44 GHz band pass filter input impedance (50 Ohms).

3-23. The 2nd LO is located on the front housing assembly A2. Its output goes to tray assembly A1, where it is filtered by a 1.44 GHz bandpass filter (A1FL4). The filtered 2nd LO output goes to the other branch of the TNC T-connector (Paragraph 3-19 above). See also Fig. 5-2. The output from the T-connector consists of the 1.44 GHz 2nd LO output and the 1.5 GHz 1st IF. The T-connector connects to the input of the 2nd mixer, which is physically located on Assembly A2A1, in the front housing assembly A2.

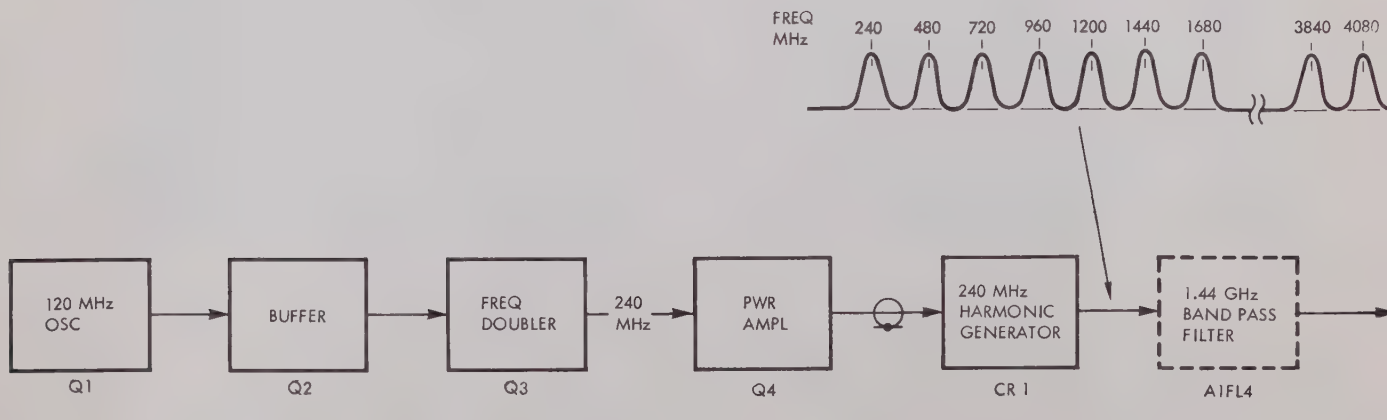


Figure 3-2. Second L.O. A2A2, Simplified Diagram

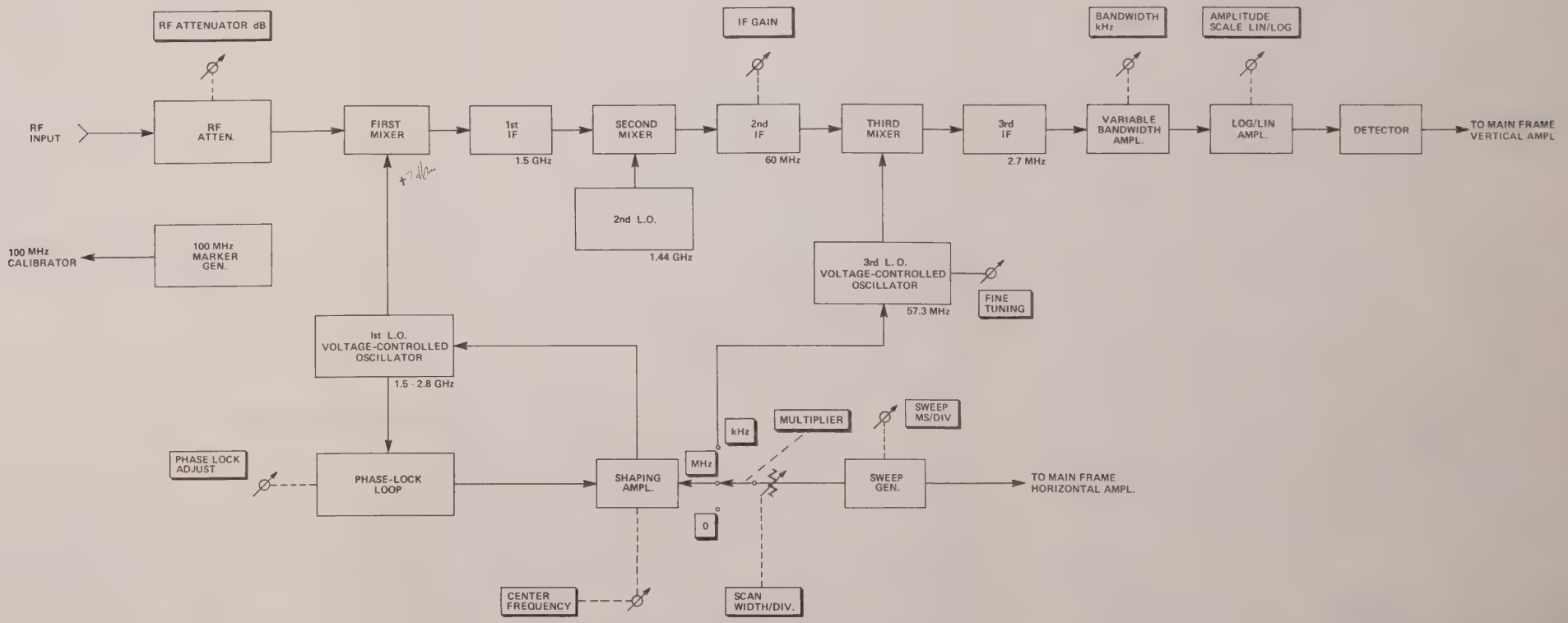


Figure 3-1. CA-6A Functional Block Diagram

3-24. 2nd Mixer/60 MHz Preamplifier. (See Fig. 5-5.) Diode CR1 mixes the outputs from the 1st IF (1.5 GHz) and the 2nd LO (at 1.44 GHz). The difference frequency (2nd IF) is 60 MHz. Preamplifier Q1 has about 20 dB gain, and its output is tuned to 60 MHz by IF transformer T1, and the trimmer C4. The base of Q1 is connected to the center arm of R44, which is the front panel AMPLITUDE SCALE CAL SCREWDRIVER ADJUSTMENT. R44 varies the base bias current of Q1; as the bias current increases, the gain of Q1 decreases. Thus, as the potential on the center arm of R44 increases towards -12 volts, the gain of Q1 is decreased. Resistors R5, R6 and R7 match the preamplifier output to the input impedance of the 60 MHz narrow band filter, Assembly A2A3.

3-25. 60 MHz Narrow Band Filter. The narrow band filter, which consists of passive LC circuits tuned to 60 MHz, provides image rejection. The response curve is shown on the schematic diagram, Fig. 5-6.

3-26. 60 MHz IF Amplifier (See Fig. 5-7.) The 60 MHz IF amplifier has three transistor stages, each of which is tuned to 60 MHz by inductors in the respective collector circuits. The gain of the 2nd stage (Q2) is variable in 10 dB steps from zero to 30 dB. Stage gain is controlled by the IF GAIN selector (S2C), and is continuously variable in each range with the VAR potentiometer (concentric with the IF GAIN selector). The gain controls vary the base bias current of Q2; as the bias current increases, the stage gain decreases. Thus, for maximum gain, the center arm of R10 moves towards a more negative potential. The gain of Q3 is controlled by potentiometer R11, in the emitter circuit of Q3. R11 is a gain calibration adjustment, used in conjunction with the front panel (AMPLITUDE SCALE) CAL screwdriver adjustment. R11 is adjusted so that when the gain of the 2nd IF is appropriately calibrated, the front panel CAL adjustment is about midrange. The calibration potentiometers in the IF GAIN selector are adjusted for 10 dB gain increments in each switch position.

3-27. 3RD CONVERTER/3RD IF.

3-28. The output from the 60 MHz IF amplifier is connected from the front housing assembly A2 to the rear housing assembly A3, and the third converter.

3-29. 3rd Converter. (See Fig. 3-3 and Fig. 5-9.) The 3rd converter circuit board contains the 3rd LO, the 3rd mixer, and the first section of the third IF amplifier, at 2.7 MHz. The input to the third mixer is matched to the output of the 2nd IF (at 50 Ohms) by resistors R30 through R32. The mixer is double balanced, with the 60 MHz IF coupled through T1, and the 3rd LO signal coupled through T2. The 2.7 MHz difference frequency goes from the center tap of the secondary winding of T1 and is then fed to the first stage of the 3rd IF.

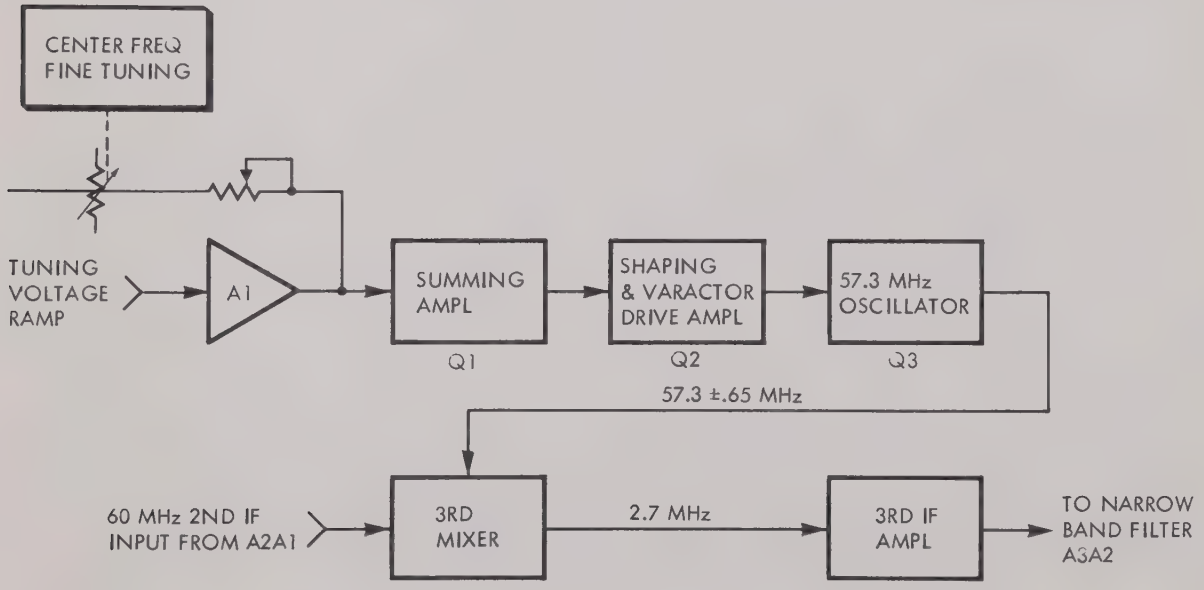


Figure 3-3. 3rd LO/3rd Mixer Block Diagram

3-30. For wide frequency scans, the sweep input to the 3rd LO is grounded by MULTIPLIER switch S7 (kHz) and the tuning voltage ramp is connected to the 1st LO. For narrow frequency scans, the situation is reversed, and the tuning voltage ramp is connected to the 3rd LO. The center frequency of the 3rd LO is always controlled by the front-panel CENTER FREQUENCY FINE TUNING control (R12), and the tuning voltage ramp sweeps the 3rd LO symmetrically about the center frequency.

3-31. For narrow frequency scans, the frequency tuning voltage ramp input is to PIN 2 of the operational amplifier A1. The gain of A1 is controlled by a display calibration adjustment, R3, which is usually set for about unity gain. The output of A1 is summed with the center frequency tuning voltage at the base of Q1. The sweep amplitude required for a full narrow band scan is ±5 volts. Potentiometer R7 adjusts the center frequency fine tuning voltage for the proper center frequency range.

3-32. Q1 is a direct-coupled amplifier that drives the varactor control amplifier Q2. Varistor CR2 and potentiometers R13 and R12 form a non-linear feedback loop from the collector to the base of Q2. CR2 has a non-linear current characteristic with respect to voltage, so that the gain of Q2 is also non-linear. Potentiometers R12 and R13 are adjusted to control the current through CR2 at the end of points of the tuning voltage ramp. In other words, R12 and R13 determine the end points of the non-linear resistance curve of CR2. In this way, the non-linear gain characteristic of Q2 compensates for the non-linear frequency tuning characteristic of varactor diode CR3.

3-33. Transistor Q3 is a varactor-tuned oscillator in a modified Colpits circuit. The output, at 57.3 ± .65 MHz, drives the double-balanced mixer (CR4 through CR6) by transformer T2. The mixer output is the 3rd IF, at 2.7 MHz. The mixer output circuit contains both series and parallel tuned circuits to pass the 2.7 MHz IF, and filter out other mixer products.

3-34. The mixer output filter drives a 2.7 MHz IF amplifier, which consists of a cascaded pair of single-tuned, capacitively-coupled amplifiers. The tuning elements are in the collector circuit of each stage. Trimmer C28 adjusts the resonant frequency of the first stage of the IF amplifier.

3-35. 2.7 MHz Narrow-band Filter. The narrow band filter circuit operates in conjunction with the variable bandwidth amplifier circuit, which follows. The function diagram, Fig. 3-4, shows the relationship of the two circuits. For the greatest bandwidth -- 200 kHz -- the filter and variable bandwidth amplifier circuits are bypassed. For all other bandwidths, the diode switch circuits route the 3rd IF through the lower signal path shown in Fig. 3-4. The bandwidth selector controls the bias in each of the four diode switch networks, such that the 2.7 MHz IF signal follows the appropriate path.

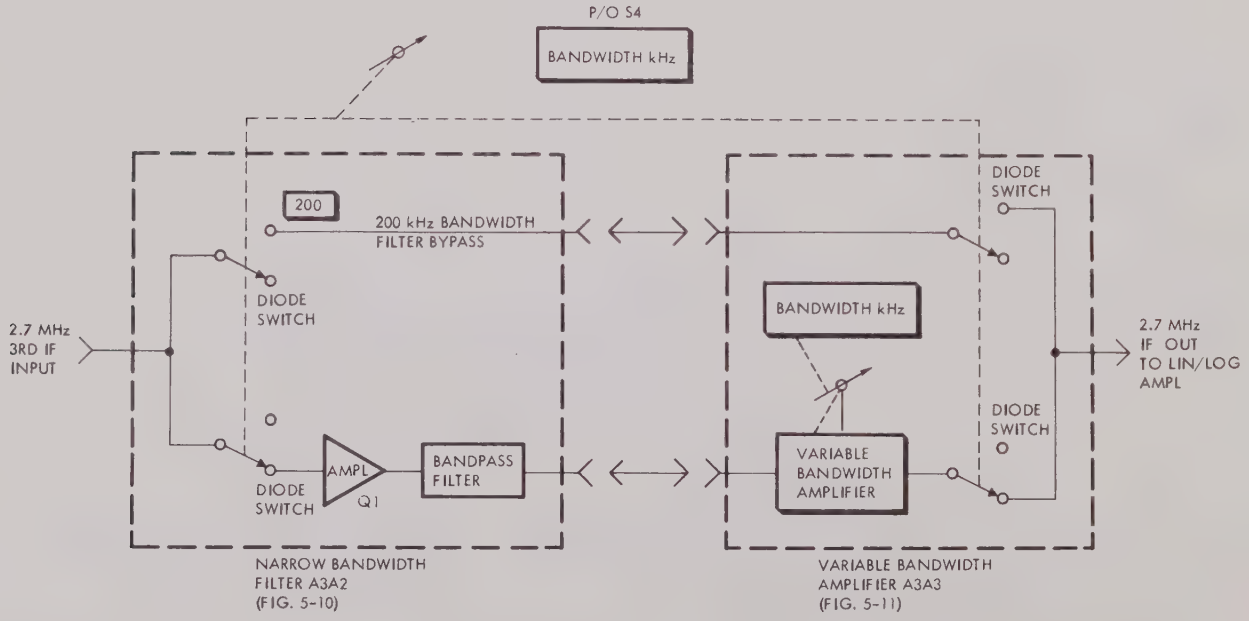


Figure 3-4. Narrow & Variable Bandwidth Filter/Amplifier Function Diagram

3-36. The actual diode switches are shown both in Figures 5-10 and 5-11. Each switch has two diodes; one is forward-biased and the other is reverse-biased at all times. For example, see diode CR1 and CR2 in Fig. 5-10. For 200 kHz bandwidth, the BANDWIDTH kHz selector switch forward-biases CR1 and back-biases CR2 with the +12 volt supply at switch S4B, pin 8 (shown in the upper left corner). A similar switching network (S4C) back-biases CR3 and forward-biases CR4, in the base circuit of Q1. For all other positions of the BANDWIDTH kHz selector, diodes CR1 and CR4 are back-biased, and CR2 and CR3 are forward-biased. The high back resistance of CR1 and the forward resistance of CR2 ensure that the bypass circuit is open. A similar pair of diode switches are in the output circuit of the variable bandwidth amplifier, for proper channel isolation.

3-37. Amplifier Q1 (Fig. 5-10) has gain of about 4, which compensates for losses in the diode switches and the filter. Filter bandwidth is approximately 30 kHz; the pass band is adjusted by C7, C10, C13 and C16. The output of the bandpass filter drives the emitter follower Q2, which in turn drives the variable bandwidth amplifier assembly A3A3.

3-38. Variable Bandwidth Amplifier. See Fig. 3-5. Basically, the variable bandwidth amplifier has three tuned circuits in cascade: the first crystal filter, a tuned amplifier, and the second crystal filter. The input amplifier, the source follower and the output amplifiers are impedance matching devices. Both crystal filters have active bandwidth control circuits that change loading on the crystal filter circuits, which changes the amplifier bandwidth.

3-39. There are two inputs to the variable bandwidth filter; one for the 200 kHz bypass, and the other for the variable bandwidth amplifier. See Fig. 5-11. The amplifier input circuit is an emitter follower, Q1, for input impedance matching. The emitter of Q1 drives the base of Q2, which is a paraphase amplifier. Q2 generates two signals that are 180° out of phase; these signals are taken respectively from the collector and emitter. The emitter circuit drives the crystal filter Y1. C7 is a phase trimmer, so that the input to Y1 is exactly 180 degrees out of phase from the collector signal. Neutralizing capacitor C6 is adjusted to compensate for the equivalent parallel capacitance of the crystal Y1. L3, C8 and VCR1 form a parallel resonant RLC circuit at the output of Y1, which is tuned to 2.7 MHz. The resistor in VCR1 is a photo-resistive diode; its impedance varies with the light intensity in VCR1. To broaden the bandwidth of the active filter circuit, the light intensity is decreased, which increases the photo-diode resistance. The filter output drives the FET source-follower circuit, Q4. Q4 has a high gate impedance to minimize loading on the filter. The output from the source of Q4 drives a 2.7 MHz tuned amplifier, Q5. The collector circuit of Q5 is tuned by L4, C16 and trimmer C17.

3-40. The collector of Q5 drives a second active crystal filter circuit, Q6/Y2; which is identical to the previous filter. The second filter drives a second source follower, Q7. Q7 drives emitter follower Q8, an impedance matching circuit. The second diode switch circuit (CR1 and CR2) operates in conjunction with the diode switch at the input of the narrow bandwidth filter circuit (assembly A3A2) and the diode switches on the 200 kHz bypass. CR3 and CR4 are in the bypass circuit. The output from the variable bandwidth circuit goes to the log/lin amplifier, A3A4.

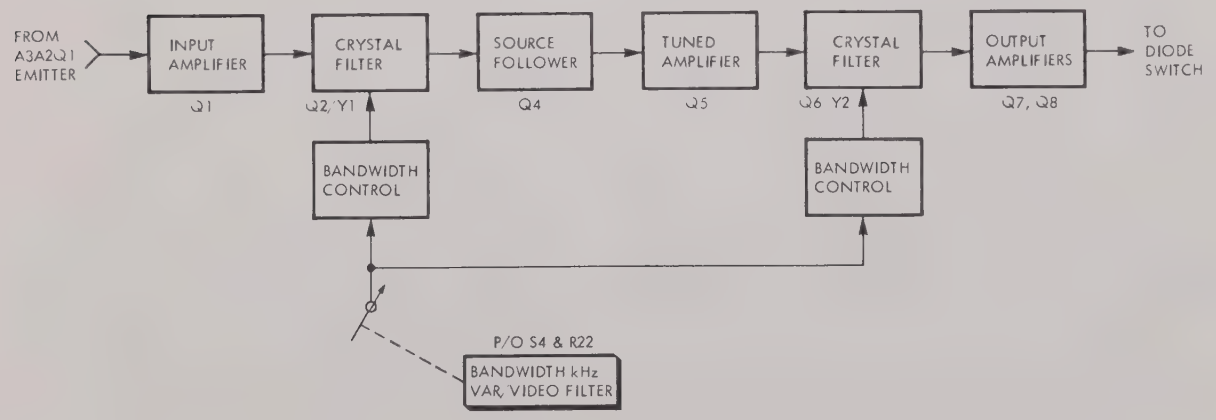


Figure 3-5. Variable Bandwidth Amplifier Block Diagram

3-41. The equivalent circuit of the bandwidth control is shown in Fig. 3-6. Essentially it is a resistive bridge with an operational amplifier for feedback control of one arm of the bridge -- a photo-resistive diode (VCR1). The amplifier drives VCR1 so that the diode impedance follows to balance the bridge when the bandwidth selector is changed. The photo-resistive diode is also temperature sensitive, so the feedback loop ensures stability.

3-42. Both control circuits have identical circuits; note, however, that one side of each bridge is in common. See Fig. 3-6 and 5-11. The common side consists of: 1) the parallel combination of the BANDWIDTH kHz selector and R16, which is between both amplifier inverting (-) inputs and ground; and 2) R15, which is between +12V and both inverting inputs. The other side of each bridge circuit has identical but separate components.

The second side of the bridge circuit that controls the first crystal filter (Q2/Y1) is formed by balance potentiometer R12 (between +12V and the non-inverting (+) input) and the photo-resistive diode circuit (VCR1), which is between the (+) input and ground. The ground return for VCR1 is through the inductor (L3) in the crystal filter tank circuit. Each operational amplifier has a transistor that supplies current to the photo-resistive diode.

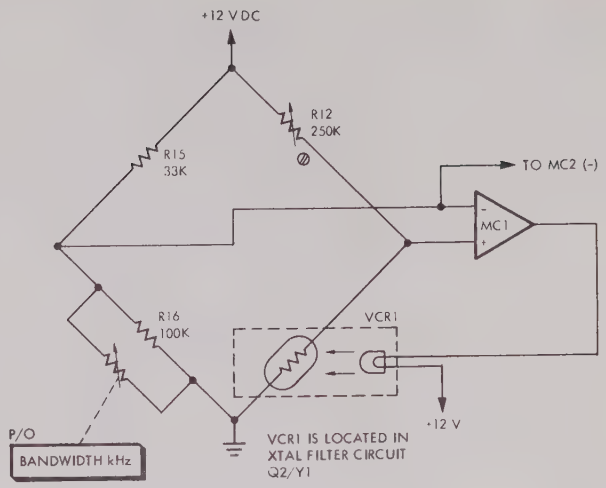


Figure 3-6. Bandwidth Control Equivalent Circuit

3-43. LOG/LIN AMPLIFIER.

3-44. In log mode, LOG/LIN AMPLIFIER gain is "compressed," so that it is proportional to the log of the input power level. The result is that the amplifier (and the spectrum analyzer) response can be calibrated in dBm.

3-45. Log Mode. The Log/Lin Amplifier has two branches; one each for log and lin modes. See Fig. 3-7. Signal path and gain mode are determined by the AMPLITUDE SCALE function selector. In log mode, the amplifier uses seven cascaded, single-transistor amplifier stages; the last six are identical. The collector circuit of each stage is tuned to 2.7 MHz and capacitively coupled to the following stage. See also Fig. 5-12. Each stage has about 10 dB gain.

For logarithmic gain "compression", each stage is sequentially overdriven in the reverse order. That is, Q7, which would have the highest input signal level, is overdriven (or "limits") first, and Q2 is overdriven last. Each stage except Q1 has a detector diode in the collector circuit. The output from all the detectors is added together by the operational summing amplifier. The result of summing the detected output from a series of sequentially limiting amplifiers is the logarithmic gain function. In other words, se-

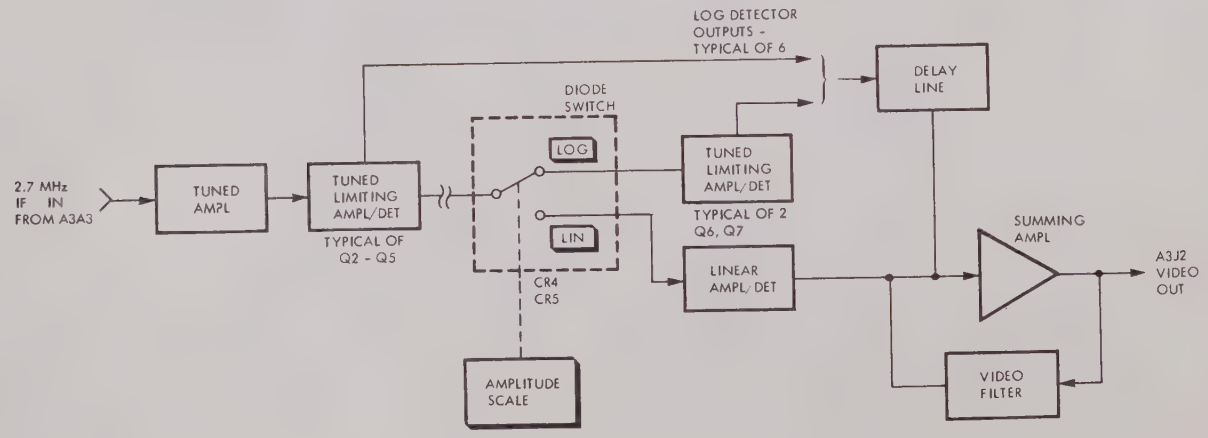


Figure 3-7. Log/Lin Amplifier Function Diagram

quentially overdriving the transistor amplifiers limits the gain, or provides gain compression. Summing the outputs results in a smooth log response curve.

3-46. Diodes CR1 through CR3, CR5, CR7 and CR8 are the log amplifier detector diodes. The detected output of each stage (Q2 through Q7) goes to a delay line, which compensates for the propagation delay through the log amplifier. The delay ensures that all of the signal components from the sequential limiter chain add simultaneously. The delay line capacitors are C9, C16, C23, C30, C39, C47 and C51; inductors are L5, L8, L11, L14, L17 and L19. The delay line output goes to the IC summing amplifier A1, which is the video output amplifier. R47, at the input of the summing amplifier A1, is a log amplifier gain calibration adjustment.

3-47. The Log/Lin Amplifier Circuit branches at the output of Q5; for log mode, diode switch CR5/CR9 directs the signal to Q6. For linear mode, the diode switch diverts the signal to the linear amplifier, Q8. Q8 has a tuned collector circuit much like the other seven stages, but the configuration is somewhat different. For linear mode, none of the amplifier stages are overdriven. Q8 is the last IF linear gain stage; its output is detected by CR12 and goes to the input of the summing amplifier. R59 is the linear gain adjust potentiometer.

3-48. The diode switch circuit consists of diode CR4, CR6 and CR9 through 11. Table 3-2 shows how the diodes operate in each amplification mode. All diodes are controlled by the AMPLITUDE SCALE selector switch.

TABLE 3-2 LOG/LIN
DIODE SWITCH FUNCTIONS

SWITCH DIODES (CR)	MODE	
	LIN	LOG
4	OFF	ON
6	ON	OFF
9	ON	OFF
10	OFF	ON
11	ON	OFF

3-49. Video Filtering. Video filtering is continuously variable with the VAR/VIDEO FILTER control (R22B) in all positions of the BANDWIDTH kHz selector. The parallel combination of R22B/C4 is in series with C2 in all positions of the BANDWIDTH kHz selector, except in the 200 kHz position. For 200 kHz, C3 (100 pf) is switched into the circuit. The video filter circuit is an RC feedback network, from the output to the input of the A1. It operates by varying the capacitive feedback. Potentiometer R22B varies the effective feedback capacitance over a range of about 100 to 1, except when the BANDWIDTH kHz selector is set to 200 kHz. In that case, the effective feedback capacitance is variable over a range of about 1000 to 1.

3-50. FREQUENCY CONTROL CIRCUITS.

3-51. The Spectrum Analyzer tuning frequency is controlled by the frequency of the 1st LO (first local oscillator), which is a voltage controlled oscillator that is tuned by the output voltage from the summing/shaping amplifier. The summing/shaping amplifier sums all frequency control inputs, and converts them to a non-linear output tuning voltage that compensates for the non-linear voltage-to-frequency characteristic of the 1st LO. There are three inputs to the summing/shaping circuit: the center frequency control, the tuning voltage ramp from the sweep generator, and the phase-lock loop voltage. All three inputs are not simultaneous. In all scan width modes, the center frequency tuning voltage goes to the summing/shaping amplifier, and the center frequency fine tuning voltage goes to the 3rd LO.

Table 3-3 shows the disposition of each frequency control voltage. See also Figure 3-8.

TABLE 3-3
FREQUENCY CONTROL FUNCTIONS

	Scan Width Multiplier Functions		
	WIDE (MHz)	NARROW (kHz)	ZERO (0)
Center Freq.	To Summing/Shaping Amplifier		
Tuning Ramp	To Summing/ Shaping Ampl.	To 3rd LO	Disabled
Phase Lock	Disabled	Optional - to Summing/ Shaping Ampl.	
Center Freq. Fine	To 3rd LO		

3-52. Tuning Ramp Generator. See Fig. 3-9 and 5-13. The tuning ramp is generated by a constant-current source (Q1 and Q2) that charges sweep capacitor C1. Sweep range resistors R1 through R6 (selected by SWEEP mS/DIV switch S1A) control the capacitor charge rate. VERNIER (R7) adjusts the sweep rate by controlling the current to the base of Q1. As the current increases, so does the sweep rate. Sweep cal potentiometer R2 calibrates the sweep when the VERNIER is fully CW.

3-53. Q3 is a darlington driver for Q4, which is the tuning voltage ramp output transistor. The ramp amplitude is 10 volts, starting at -5V, and is positive going. The output of Q4 goes three places: First, via J1-26 to the SCAN WIDTH/DIV selector, where it is attenuated for the proper scan width, and switched to the first LO (for wide scans) or to the third LO (for narrow scans). Second, the ramp re-enters the assembly at J1-10, where it is inverted by a unity-gain IC amplifier (A9) that drives the main frame horizontal deflection circuits. Third, for sweep reset and blanking, Q4 drives Schmitt trigger ST1 (part of MC1) that switches when the ramp reaches +5 volts. Balance potentiometer R11 adjusts the trigger level. The Schmitt trigger drives a blanking flip-flop (set-reset Flip-flop FF1, part of MC2) that drives both the CRT retrace blanking circuitry in the main frame, and the sweep capacitor discharge circuit. The blanking pulse also goes to the main frame rear-panel SYNC OUT connector. See Fig. 3-10.

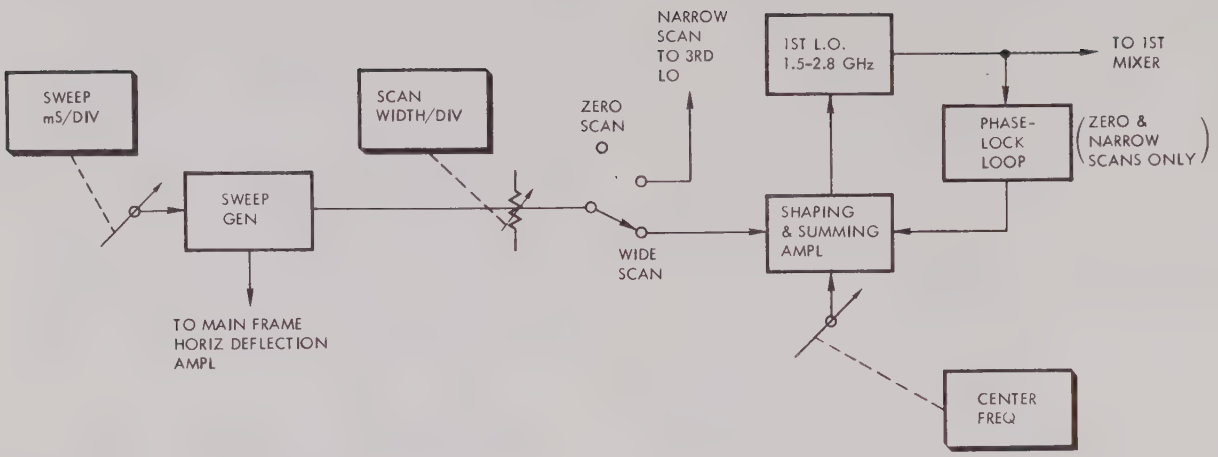


Figure 3-8. Frequency Control Function Diagram

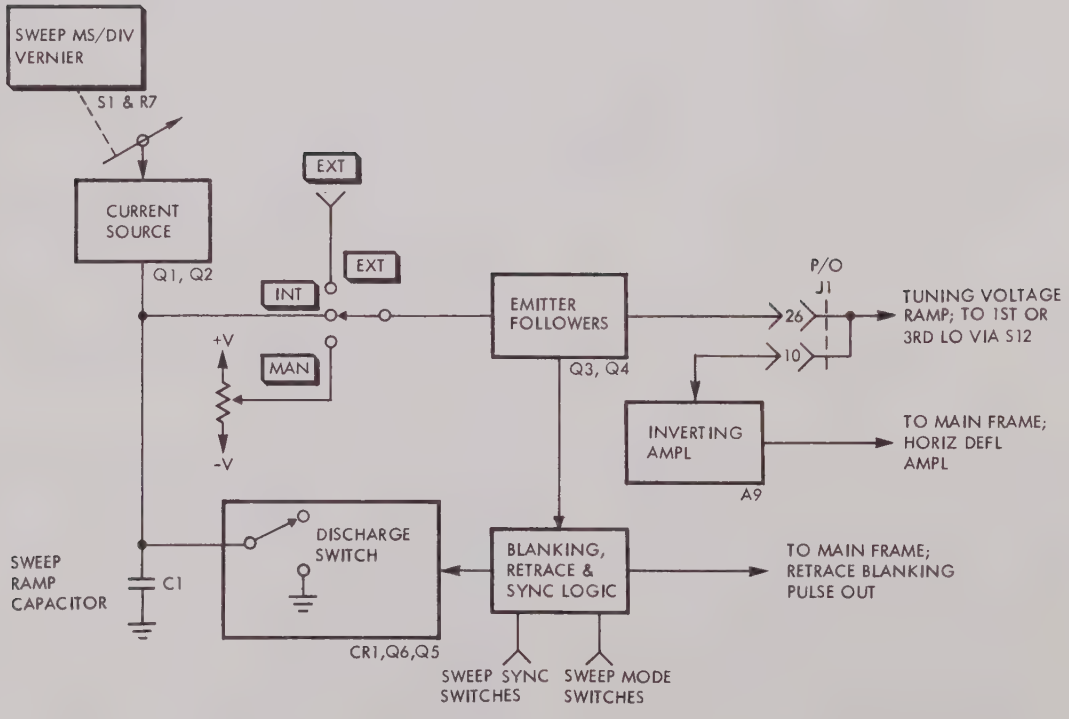
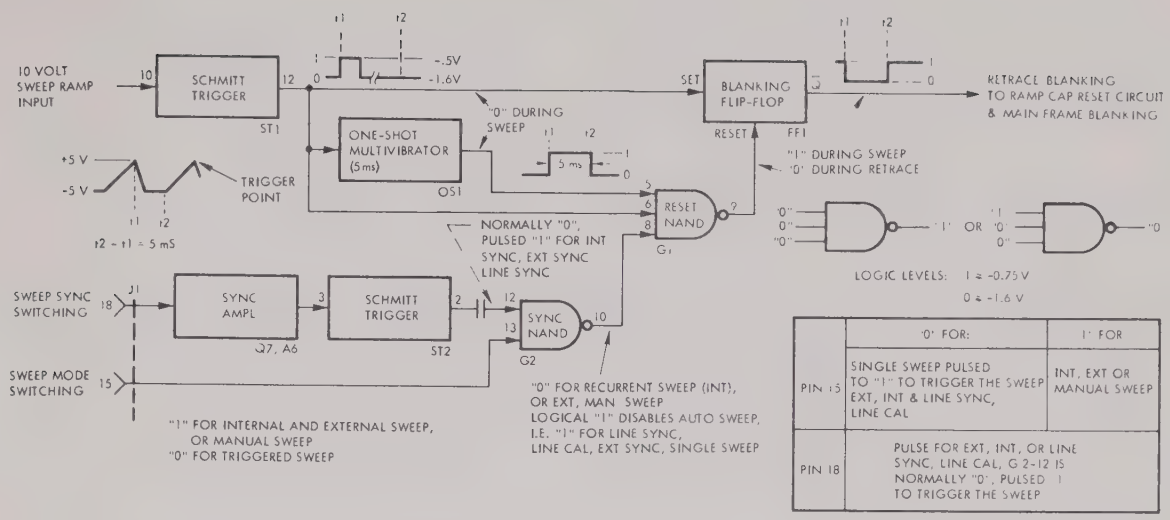


Figure 3-9. Sweep Generator Function Diagram



	"0" FOR:	"1" FOR
PIN 15	SINGLE SWEEP PULSED TO "1" TO TRIGGER THE SWEEP EXT, INT & LINE SYNC, LINE CAL	INT, EXT OR MANUAL SWEEP
PIN 18	PULSE FOR EXT, INT, OR LINE SYNC, LINE CAL, G 2-12 IS NORMALLY "0", PULSED 1 TO TRIGGER THE SWEEP	

Figure 3-10. Blanking, Retrace and Sync Logic Block Diagram

3-54. The reset/blanking pulse is negative-going (to about -1.6 V), which turns on Q6 in the sweep ramp discharge circuit. Q6 turns on Q5, and C1 discharges through CR1 and Q5. As C1 discharges, the ST1 resets. The blanking pulse duration is determined by a one-shot multi-vibrator (OS1) that is triggered by the Schmitt trigger ST1. After 5 mS, the one-shot resets, and its output goes to the reset NAND gate G1 (part of MC3). G1 resets the blanking flip-flop FF1 when all of its inputs are logical zero[1]. For free-running sweep, the output of G2 is low, and since both ST1 and OS1 have reset, all inputs to G1 are low, and FF1 resets.

3-55. Sync and Sweep Mode Selection. (Fig. 3-10.) Pushbuttons S12 through S15 select the sweep mode; pushbuttons S16 through S19 select the sweep synchronization. Both switch sets are interlocked for proper sweep/sync control in any mode. These switches have two functions: they control the sweep and sync logic levels at terminals J1-15 and J1-18, respectively, and they connect manual or external sweep inputs to the sweep circuit.

3-56. The sweep and sync inputs control the reset and sync NAND gates, G1 and G2. For internal (recurrent) sweep, pushbutton S13 is depressed, which holds the input to the sync NAND gate G2 at a logical 1; that holds the output of G2 at 0, which allows the blanking flip-flop to generate retrace/blanking pulses automatically. In contrast, logical 0 to G2 holds its output at 1, which then holds the output of G1 at 0. In turn, the ramp capacitor discharge switch is held closed, which disables the sweep generator. This condition holds for single sweep, external sync, internal sync, or line sync. Note that the schematic diagram (Fig. 5-13) shows all pushbutton switches released.

3-57. Sweep Synchronization (Fig. 3-10.) A sweep cycle is initiated each time a sync pulse is applied to the sweep sync circuit (J1, Pin 18). The sync amplifier drives Schmitt trigger ST2, which generates a logical 1 pulse at the input of gate G2. G2 (Pin 10) switches momentarily to a logical 0. Since the ramp capacitor has been discharged and the sweep circuit has reset, all the other inputs to NAND gate G1 have since gone to 0. When all three inputs are logical 0, the output reverts to a logical 1, which resets the blanking flip-flop. At that point the beam in the CRT in the display is unblanked, the ramp capacitor discharge switch opens, and a new sweep starts.

3-58. As before, the ramp capacitor charges until the Schmitt trigger switches and sets the $\overline{Q}$ output of the blanking flip-flop to 0. The CRT display is blanked, and the sweep ramp capacitor discharges. During the time the sweep ramp capacitor charges, the input to the sync NAND gate G2 (at Pin 12) returns to 0, and the NAND gate output has returned to 1. That disables the sweep generator until the next sweep sync or trigger pulse restarts the sweep.

3-59. For manual sweep, the sweep mode input is held at logical 1, and switch S15A connects the MANUAL sweep potentiometer to the input of the emitter follower circuit (Q3 and Q4). For the external sweep input, the ramp voltage is supplied externally.

3-60. Summing/Shaping Amplifier. The summing/shaping function is performed by a differential amplifier with a nonlinear feedback loop. The summing amplifier has two functions: First, it sums the center frequency tuning voltage with either the tuning voltage ramp (wide frequency scans)

[1]The NAND gate output is a logical 1 only when all inputs are at logical 0. Logical 0 is -1.6 volts, and a logical 1 is 0 volts, or ground.

or the phase lock error voltage (narrow frequency scans). For wide scans, the tuning voltage ramp is summed in such a way that the frequency sweep of the 1st LO is symmetrical about the center frequency. Second, the shaping network (the feedback network in Fig. 3-11) converts a linear input voltage to a non-linear output voltage that compensates for the non-linear frequency tuning characteristic of the 1st LO.

3-61. The feedback network increases the amplifier gain as the input voltage increases. It works by decreasing the negative feedback, so that the output voltage increases exponentially with the input voltage.

In one sense, the feedback network is a sequential shunt network; the diodes merely determine at what voltage the shunt starts to affect the circuit operation. Fig. 3-11 shows a simplified circuit. When the feedback voltage at Point A is more negative than the voltage on the anode of CR_S the diode conducts R73 and R_S form a voltage divider, which decreases the negative feedback as each additional diode becomes forward biased. Figure 3-12 shows a typical diode circuit. Figure 3-13 shows the resultant 1st LO tuning curve.

3-62. PHASE LOCK LOOP.

3-63. For narrow and zero scan widths, the 3rd LO is swept, and the 1st LO operates at a fixed frequency. Under these conditions, display resolution is limited by the stability of the 1st LO. For low FM and drift, the 1st LO is therefore phase locked to a stable crystal reference oscillator. Fig. 3-14 is a block diagram of the phase lock loop. A 17 MHz crystal controlled oscillator (Assembly A4) provides a stable reference signal for the phase lock loop. The reference oscillator frequency can be adjusted or "pulled" over a range of 90 kHz by the front panel PHASE LOCK ADJUST control. The output of the 17 MHz oscillator drives a comb generator that produces harmonics every 17 MHz out to at least 2.8 GHz. The 17 MHz comb is then attenuated 10 dB, and mixed with the output of the 1st LO. The mixer is a double balanced unit, and is in a sealed assembly.

3-64. In order for the phase lock loop to operate properly, the 17 MHz reference oscillator is pulled, or tuned, so that one of the harmonics from the comb generator is exactly 11.85 MHz away from the 1st LO frequency. The result is an 11.85 MHz intermediate frequency. The 11.85 MHz IF is filtered through a bandpass filter, and then amplified and limited. The limiter eliminates any amplitude fluctuations in the phase lock mixer output, to minimize phase jitter. The limiter output is a constant-amplitude signal that goes to the 11.85 MHz phase detector.

3-65. The phase detector has two inputs; one from the limiter circuit, and the other from an 11.85 MHz crystal reference oscillator. The phase detector is in fact a double-balanced modulator circuit that is used to detect the difference frequency between the reference oscillator and limiter output. In fact, the difference frequency is a zero-beat, or null.

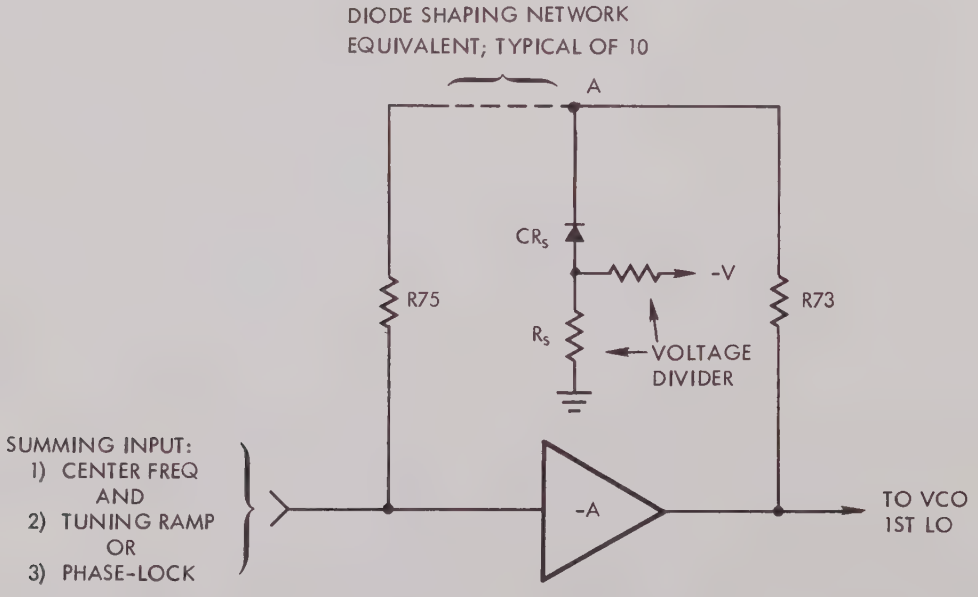


Figure 3-11. Summing/Shaping Amplifier Simplified Diagram

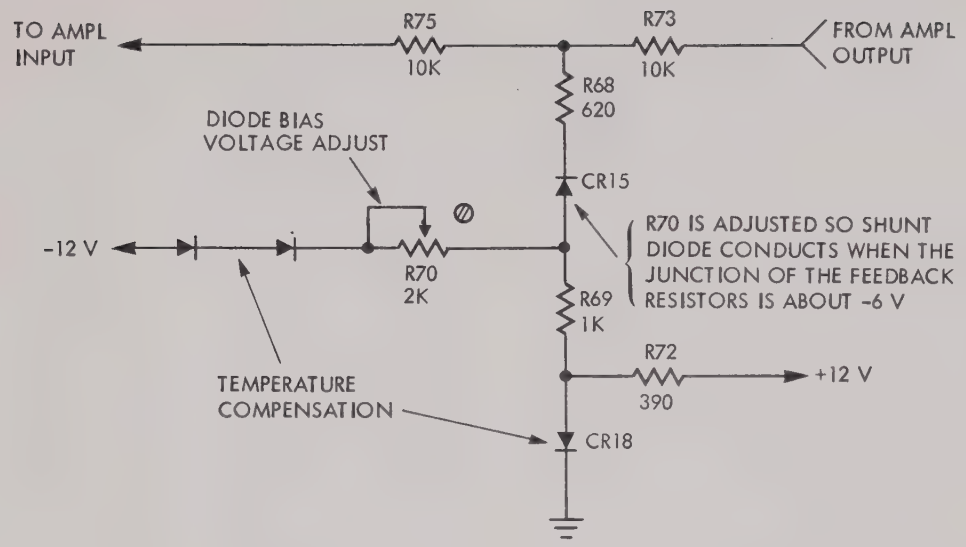


Figure 3-12. Typical Diode Circuit

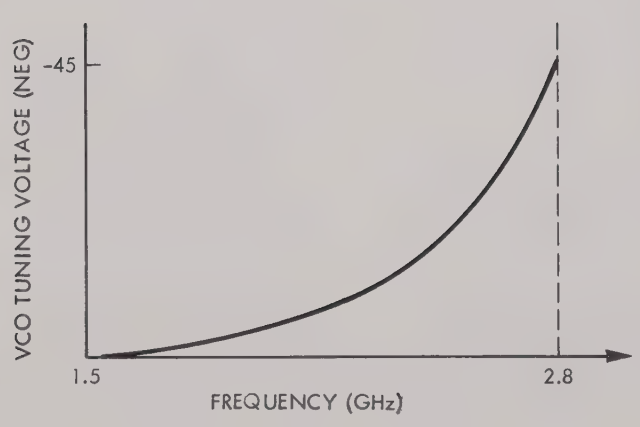


Figure 3-13. 1st LO Frequency Tuning Curve

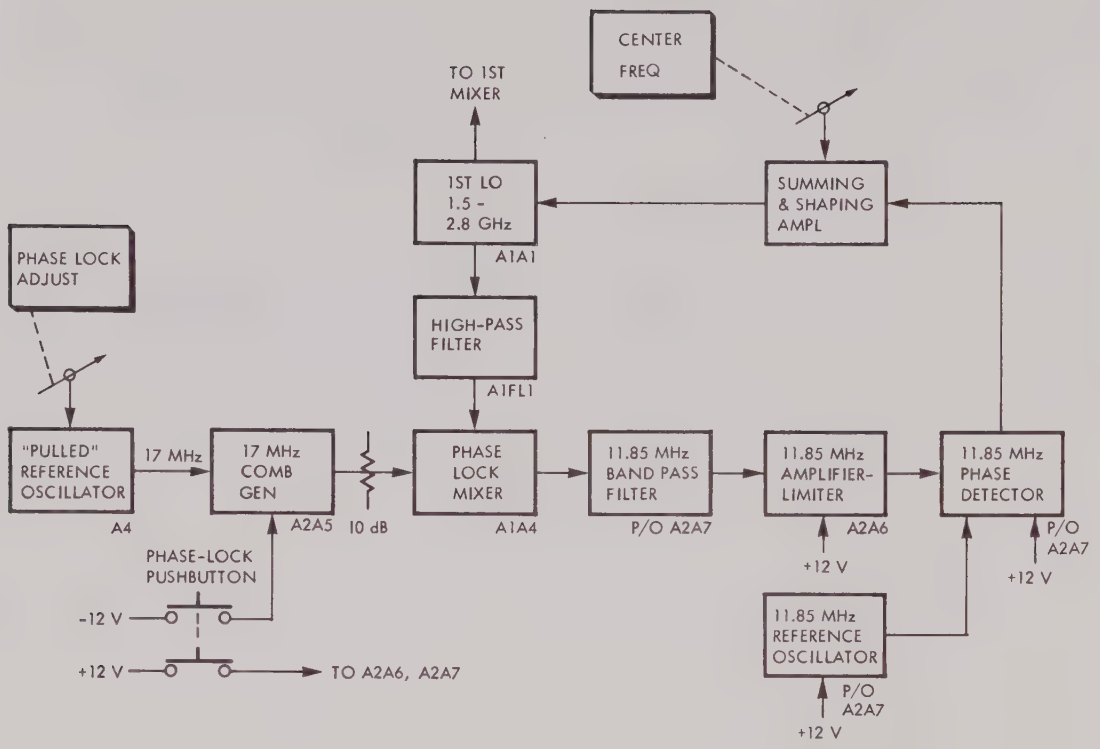


Figure 3-14. Phase-Lock Loop Block Diagram

3-66. The output from the phase detector goes to the summing/shaping amplifier, where it is combined with the input from the center frequency tuning voltage control, as discussed previously. The phase detector output voltage is really a frequency correction voltage, and it shifts the frequency of the 1st LO to compensate for the detected phase difference.

3-67. The phase lock loop is enabled by depressing either the zero or the kHz multiplier pushbutton, and then depressing the red pushbutton associated with the PHASE LOCK ADJUST control. The phase lock pushbutton connects the ±12 volt power supplies to the appropriate phase lock loop sub-assemblies.

3-68. 17 MHz Oscillator. See Fig. 5-15. The frequency of oscillator Q1 is controlled by a series-resonant crystal Y1. Phase lock adjust capacitor C1 permits tuning (or pulling) of the oscillator frequency over a range of about 90 kHz. L1 and C2 are resonant at 17 MHz and trimmed by C2. Similarly, the output circuit of Q1 is tuned at 17 MHz by trimmer C5 and transformer T1. The oscillator output goes to a 17 MHz power amplifier, Assembly A2A5.

3-69. 17 MHz Amplifier/Harmonic Generator. See Fig. 5-16. The crystal oscillator output is amplified and buffered by amplifier Q1, which provides sufficient gain to drive the comb (harmonic) generator. Resistors R1 through R3 match the power amplifier input to the oscillator output. Q1 has a single-tuned output that is trimmed by capacitor C3. The oscillator output is transformer coupled to the comb generator. The comb generator uses a step-recovery diode CR1, that produces harmonics of 17 MHz out to 2.8 GHz. C5 and L2 are tuned to 17 MHz and are formed by brass tubing, a slug, and pigtails. Teflon tape insulates the slug from the brass tubing. The comb generator output is terminated in 50Ω by resistors R8 through R10. The comb generator output is coupled through a 10 dB attenuator A2AT1, and then to the phase lock mixer assembly. The attenuator is used to minimize VSWR.

3-70. Phase Lock Mixer. The phase lock mixer is a separate sealed assembly. It has two inputs; one from the 1st LO, and the other from the harmonic generator. The 1st LO output is filtered by 1.5 GHz highpass filter A1A1, which prevents feed-through of the 17 MHz harmonics to the 1st LO and the first mixer circuit. The output of the mixer is connected to an 11.85 MHz bandpass filter. In order for the phase lock loop to operate properly, the front-panel PHASE LOCK ADJUST control is tuned so that one of the harmonics of the 17 MHz oscillator is 11.85 MHz away from the 1st LO frequency. The 11.85 MHz difference frequency is then filtered by the bandpass filter, which is part of assembly A2A7 and is shown in Fig. 5-18. The output of the bandpass filter then goes to the 11.85 MHz amplifier and limiter circuit, assembly A2A6.

3-71. 11.85 MHz Amplifier/Limiter. See Fig. 5-17. Q1 is a single-stage RF amplifier that drives the limiter A1. A1 is a high-gain IC amplifier that limits when input signals are greater than about 600 μV. The limiter ensures a constant-amplitude input to the 11.85 MHz phase detector, which follows.

3-72. 11.85 MHz Phase Detector. See Fig. 5-18. The reference oscillator is a single-stage crystal oscillator that operates at 11.85 MHz. Its output is transformer-coupled to a 10 dB attenuator (R5 through R7), and then through another transformer (T3) to the phase detector. The other phase detector input is from the limiter, through transformer T2. The phase detector circuit is a double-balanced circuit similar to the 3rd mixer. The double balanced circuit characteristically supresses the two mixer input frequencies, leaving only the sum and difference frequencies. Since the phase lock loop is adjusted so that the input frequencies are identical, the difference frequency is a zero-beat. The output is a DC voltage that is sensitive to the relative phase of the input signals. In fact, when the instantaneous voltages applied to the phase detector are 90° out of phase, the detector output is 0 V. If the relative phases of the input signals should change, a DC voltage appears at the center top of T2. The maximum voltage output occurs when the signal voltage input is either in phase with, or 180° out of phase with, the reference signal. Once the 1st LO is phase locked, any frequency variation causes an error voltage to be fed back to the summing/shaping amplifier to correct the frequency drift.

3-73. 100 MHz CALIBRATOR/MARKER GENERATOR.

3-74. The 100 MHz calibrator supplies an auxiliary calibration signal to the front-panel 100 MHz CALIBRATOR connector. There are two calibrator modes: in one mode, the calibrator supplies a 100 MHz signal at -40 dBm for frequency and amplitude calibration. In the other mode, the calibrator generates a frequency comb that supplies harmonics of 100 MHz out to at least 1.3 GHz. In the latter mode, the amplitude of the fundamental and the harmonics is uncalibrated. Fig. 3-15 shows the circuit functions in the calibrator. The calibrator/oscillator circuit is disabled unless either the -40 dBm or the MARKER pushbutton is depressed. For the amplitude calibration, the -40 dBm pushbutton also drives relay K1, selecting the calibrator output function. The output passes through a bandpass circuit to the front-panel output through the 1.3 GHz lowpass filter (A1FL5). For frequency calibration, the 100 MHz crystal oscillator drives a step-recovery diode that generates the harmonics. The harmonic generator output is inductively coupled to the calibrator output.

3-75. Fig. 5-15 shows the calibrator schematic diagram. Q1 is the 100 MHz oscillator. The collector circuit is tuned to 100 MHz, and then matched to 50Ω by R5 through R7. The mode selection relay is at the output of the matching pad. The emitter circuit of Q1 is connected through the front panel pushbutton selector switches to either of two potentiometers, which are used for amplitude adjustment. R4 is switched into the circuit for amplitude calibration function, and adjusted so the output is -40 dBm. For markers, R3 is switched into the circuit, and it is adjusted for optimum signal amplitude for driving the marker generator.

3-76. For the -40 dBm output signal, the reed relay switches so the output goes through a bandpass filter (C6 and L4) to an impedance matching network (R11 through R13), and then through the 1.3 GHz low-pass filter to the front-panel output connector. For the marker generator, the relay is switched so that the 100 MHz signal drives a step-recovery diode, CR1. C5 and L3 form a broadly tuned, 100 MHz trap that reduces the amplitude of the fundamental and the first few harmonics. C7 is tuned to match the diode, and R8 through R10 are an impedance matching network (50Ω). The output of the marker generator is coupled with a loop to the calibrator output. For calibrator/marker operation, the 100 MHz calibrator output is connected to the CA-6A RF input with a cable supplied with the plug-in unit.

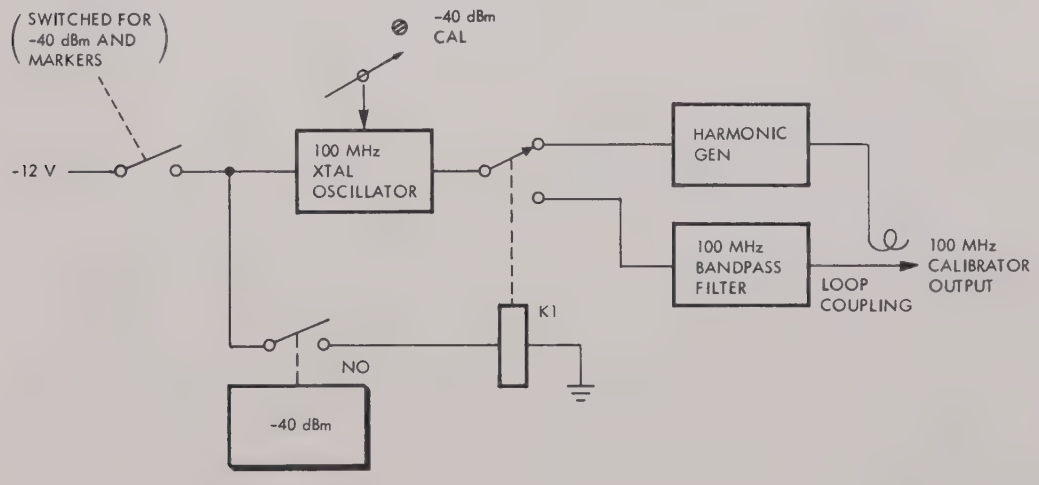


Figure 3-15. 100 MHz Calibrator Function Diagram

SECTION IV

MAINTENANCE

4-1. PERFORMANCE TESTS.

4-2. GENERAL.

The tests determine if the performance of the CA-6A is within published specifications. If not, see the appropriate alignment procedure. If the unit will not align properly, troubleshoot the appropriate sections. See also the troubleshooting tables included in Section IV of this manual.

4-3. PERFORMANCE TEST EQUIPMENT LIST.

The following test equipment (or equivalent) is required:

Comb Generator:	HP Model 8406A
Test Oscillator:	HP Model 651A
Time Mark Generator:	Tektronix Type 184A
Signal Generator:	Singer Model 6201 (2 required)
Frequency Extender:	Singer Model 6202 (1 required)
Sweep Oscillator:	Singer Model 6600 with 6608 Plug-in
Attenuator:	10 dB
Precision Step Attenuators:	Kay 431-C and 1/432-D
Resistive T:	Microlab DA-3FB
Power Meter:	HP Model 432A

4-4. PRELIMINARY SETUP INFORMATION.

Install the Model CA-6A in a properly operating MF-6A or SMF-6A main frame. Allow 30 minutes for warm-up. Follow the procedure in Paragraph 2-9 for initial adjustment of the main frame and the CA-6A. Set the CA-6A controls as listed below before starting the performance tests. Conduct all tests at room ambient temperature and humidity, and 115 VRMS, 60 Hz nominal power source.

NOTES

- Conduct all tests in the sequence given.
- Do NOT make any internal adjustments for performance tests.
- Do not change any control settings unless instructed.

Set CA-6A controls as follows:

CENTER FREQUENCY MHz 650
SCAN WIDTH/DIV 130
SCAN WIDTH/DIV VARIABLE . . . . . CAL (fully cw)
MULTIPLIER MHz . . . . . Depress
SWEEP mS/DIV 3
SWEEP mS/DIV VERNIER . . . . . CAL (fully cw)
IF GAIN . . . . . LOG 0
IF GAIN VAR . . . . . CAL (fully cw)
RF ATTENUATION dB 10
SWEEP INT . . . . . Depress
BANDWIDTH kHz 20
VAR/VIDEO FILTER . . . . . MAX BW (fully cw)

4-5. CENTER FREQUENCY ACCURACY.

a. Connect the comb generator output to the CA-6A RF INPUT. Set the comb frequency to 100 MHz. Adjust the main frame for the appropriate display. Adjust the comb amplitude so all harmonics are about half-scale on the CRT. If the baseline rises, adjust the FINE TUNING control until the baseline returns to the bottom of the graticule.

b. Set the SCAN WIDTH/DIV to 10, and the BANDWIDTH kHz to 20.

c. Turn the CENTER FREQUENCY control toward zero, so the zero pip is centered on the CRT at f_o. Note the CENTER FREQUENCY control setting. It should be between 0 and 25 MHz.

d. Repeat Step c. at 100 MHz, and at multiples of 100 MHz through 1300 MHz. Center frequency accuracy in all cases should be within ± 25 MHz.

4-6. SCAN WIDTH ACCURACY (Wideband).

a. Set the CA-6A controls as follows:

CENTER FREQUENCY 650
SCAN WIDTH/DIV 130
BANDWIDTH kHz 20

b. Set the CENTER FREQUENCY control so the zero pip coincides with the left edge of the graticule.

c. Measure the scan width by counting the number of harmonics to the right of the zero pip. Convert the count to frequency. Interpolate, if necessary. The scan width should be between 1170 MHz and 1430 MHz.

d. Set the SCAN WIDTH/DIV to 30, and repeat Step b. There should be three pips to the right of the zero pip.

e. Note the scan width. It should be 300 ± 30 MHz.

f. Increase the CENTER FREQUENCY by 100 MHz so the 100 MHz harmonic coincides with the left edge of the graticule. Note the scan width, as in Step e. Use 10 MHz markers to interpolate, if necessary.

g. Repeat Step f. for each harmonic, every 100 MHz. Scan width should be 300 ± 10 MHz.

h. Set the SCAN WIDTH/DIV to 10, and repeat Step b. One pip should appear at the right edge of the

graticule. The scan width should be 100 ± 10 MHz. Use 10 MHz markers.

i. Repeat Step f. for each 100 MHz harmonic across the band. Scan width in all cases should be 100 ± 10 MHz.

4-7. SCAN WIDTH ACCURACY (Narrowband).

a. Set the CA-6A controls as follows:

CENTER FREQUENCY MHz..... 100
SCAN WIDTH/DIV..... 130
MULTIPLIER KHz ..... Depress
BANDWIDTH kHz..... 10
VAR/VIDEO FILTER..... Fully ccw
SWEEP mS/DIV 10
IF GAIN ..... LOG 0
RF ATTENUATOR dB..... 0
SWEEP INT ..... Depress

b. Connect the equipment as shown in Figure 4-1. Use the 6201 frequency counter or another counter. Set the signal generator output to 100 MHz at -40 dBm. Center the display, then phase lock the signal by depressing the phase lock pushbutton, and tuning the PHASE LOCK ADJUST until locked; then center the pip at f_o. Set the external attenuators for zero attenuation.

c. Amplitude modulate the signal generator at 650 kHz. Adjust the frequency of the modulating oscillator until the two sideband pips coincide with the two extreme graticule lines.

d. Depress the Model 6201 DEPRESS FOR COUNT IN pushbutton, and note the indication on the frequency counter. It should be 650 ± 65 kHz; multiply by two for scan width.

e. Set the CA-6A controls as follows:

SCAN WIDTH/DIV..... 30
BANDWIDTH kHz 5

Adjust the CENTER FREQUENCY FINE TUNING so the pip coincides with the left edge of the graticule. Then, adjust the modulating oscillator frequency so the right sideband pip coincides with the right edge of the graticule.

f. Note the frequency counter indication. It should be 300 ± 30 kHz.

g. Repeat Step e. for all scan widths indicated in the following table. Set other parameters as indicated. Sweep speed should be 30 mS/DIV.

SCAN WIDTH/ DIV	BANDWIDTH (Hz)	Modulating Frequency (kHz)	Counter Reading (kHz)
10	1000	100	100 ± 10
3	500	30	30 ± 3
1	200	10	10 ± .1
.3	200	3	3 ± .3

4-8. RESOLUTION BANDWIDTH.

a. Set the modulating oscillator to 1 kHz.

b. Set the CA-6A SCAN WIDTH/DIV VARIABLE and CENTER FREQUENCY FINE TUNING so the signal is at one edge of graticule, and one of the sideband signals is at the other edge. Then disconnect the modulating oscillator.

c. Center the signal on the display with the FINE TUNING.

d. Set the IF GAIN to LIN.

e. Adjust the signal generator output level for a full-scale LIN display (the signal peak should be at 1.0 on the LIN scale).

f. Note the width of the signal display at 0.7 on the LIN scale. It should be 200 ± 40 Hz (2 ± 0.4 divisions).

g. Set BANDWIDTH kHz to .5.

h. Note the width of the signal display at 0.7 on the LIN scale. It should be 500 ± 100 Hz (5 ± 1 division).

i. Set BANDWIDTH kHz to 1.

j. Repeat Step e. Then adjust the SCAN WIDTH/

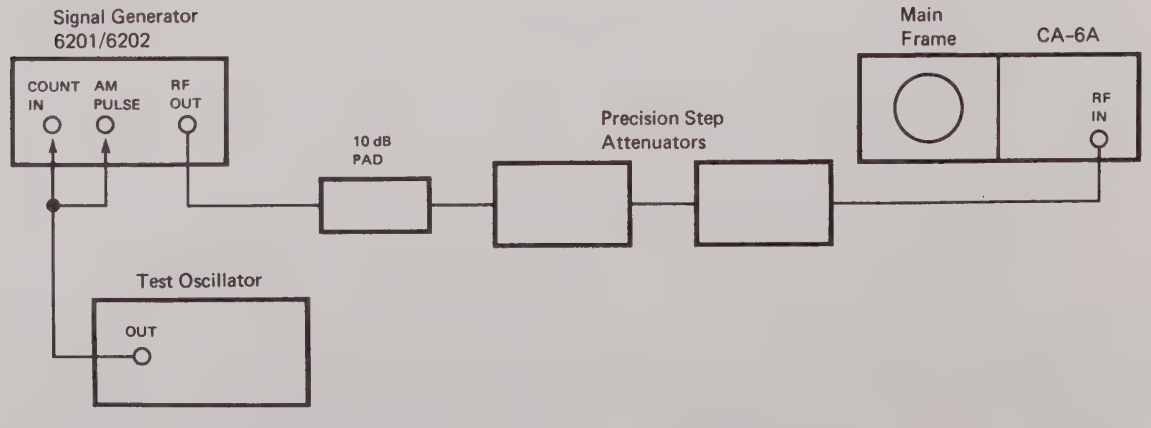


Figure 4-1. Performance Test Setup No. 1

VARIABLE until the skirts of the signal intersect the left and right edges of the graticule at .7 on the LIN scale. Determine the scan width by modulating the signal generator.

NOTE

Reduce the bandwidth as necessary to resolve the modulation sidebands.

Disconnect the modulation.

k. The scan width should be 1000 ± 200 Hz.

l. Set the BANDWIDTH kHz to 2, and repeat Step j.

m. The scan width should be 2000 ± 400 Hz.

n. Set the BANDWIDTH kHz to 5, and repeat Step j.

o. The scan width should be 5 ± 1 kHz.

p. Set the BANDWIDTH kHz to 10, and repeat Step j.

q. The scan width should be 10 ± 2 kHz.

r. Set the BANDWIDTH kHz to 20, and repeat Step j.

s. The scan width should be 20 ± 4 kHz.

t. Set the BANDWIDTH kHz to 200, and repeat Step j.

u. The scan width should be 200 ± 40 kHz.

v. Set the BANDWIDTH kHz to VAR, and the VAR/VIDEO FILTER fully clockwise, and repeat Step j.

w. The scan width should be 20 ± 4 kHz.

x. Set the VAR/VIDEO FILTER fully counter clockwise, and repeat Steps a. through f.

y. Disconnect the modulating signal generator, and set the VAR/VIDEO FILTER fully clockwise.

4-9. SENSITIVITY.

a. Set the signal generator output to minimum.

b. Set BANDWIDTH kHz to .2; check to ensure the baseline is at the bottom of the graticule. If necessary, reset the main frame V POS adjust.

c. Set the CA-6A controls as follows:

SCAN WIDTH/DIV..... 130
SCAN WIDTH/DIV VARIABLE..... CAL
BANDWIDTH kHz 200
MULTIPLIER KHz ..... Depress
VAR/VIDEO FILTER..... Fully ccw
SWEEP mS/DIV..... 10
IF GAIN ..... LIN
RF ATTENUATION dB 0

d. Set the signal generator output at -60 dBm, in CW mode. The external step attenuators should be set to zero.

e. Center and phase lock the signal. If necessary, adjust the main frame V POS so the baseline coincides with the bottom of the graticule.

f. Adjust the IF GAIN/VAR control so that the baseline is at the 0.2 horizontal graticule division on the LIN scale. Decrease the signal generator output until the peak of the signal is at the .4 horizontal graticule division on the LIN scale. Note the signal generator output level in dBm.

g. The signal generator output level should be $\leq$ -82 dBm, for -92 dBm input to the analyzer (note the 10 dB pad).

h. Repeat Steps f. and g. for each SCAN WIDTH/DIV and BANDWIDTH kHz switch position listed in the following table. The generator output should be equal to or less than the output listed in the table.

BANDWIDTH kHz	SCAN WIDTH/ DIV (KHz)	Sensitivity (S+N=2N, dBm)	Generator Output (dBm)
20	10	$\leq$-102	$\leq$- 92
2	1	$\leq$-110	$\leq$-100
.2	.3	$\leq$-115	$\leq$-105

4-10. SCALE ACCURACY (LINEAR).

a. Set the IF GAIN/VAR fully counterclockwise. If necessary, adjust the main frame V POS so the baseline coincides with the bottom of the graticule. Set the other controls as follows:

SWEEP mS/DIV..... 3
BANDWIDTH kHz 5
SCAN WIDTH/DIV..... 3
MULTIPLIER KHz..... Depress

b. Set the signal generator output for a full-scale LIN display (1.0 the LIN scale), at 100 MHz.

c. Add attenuation to decrease the signal amplitude to 0.8 on the LIN scale.

d. Attenuation should be from 1.4 to 2.5 dB.

e. Repeat Step c. for each value listed below. The attenuation should be within the limits shown.

Amplitude (LIN)	Attenuation (dB)
0.6	3.7 - 5.2
0.4	6.9 - 9.1
0.2	12.0 - 16.5

f. Reset the external attenuation to zero.

4-11. SCALE ACCURACY (LOG).

a. Set the CA-6A controls as follows:

IF GAIN..... LOG 0
IF GAIN/VAR ..... CAL(Max cw)
BANDWIDTH kHz 20
VAR/VIDEO FILTER ..... MAX CW
SCAN WIDTH/DIV..... 130
PHASE LOCK ADJUST ..... Depress

b. Phase lock the signal, adjust the input signal amplitude, adjust the CA-6A center frequency, SWEEP mS/DIV and sweep triggering for a convenient display. Set the external attenuation to zero. If necessary, adjust the main frame V POS so the baseline is at the graticule bottom.

c. Adjust the signal generator output for a full-scale LOG display. With the external step attenuators, decrease the signal level until the peak of the signal is at the 10 dB division on the LOG scale. The external attenuation should be 10 ± 2 dB.

d. Repeat Step b. for each division of the graticule. The external attenuation should be within ± 2 dB of the appropriate graticule division, as shown below.

dB LOG Scale	External Attenuation (dB)
20	20 ± 2
30	30 ± 2
40	40 ± 2
50	50 ± 2
60	60 ± 2

e. Reset the external attenuation to zero.

4-12. IMAGE RESPONSES.

a. Change the signal generator frequency to 500 MHz, at -30 dBm. Set the IF GAIN to LOG 10.

b. Release the CA-6A phase lock. Center the signal on the display with the CENTER FREQUENCY. Phase lock the display again.

c. Turn the signal generator tuning controls and note the level of any image responses on the display moving in the opposite direction of the main response. All image responses should be more than 60 dB down from the main response.

4-13. INTERMODULATION DISTORTION.

a. Connect the equipment as shown in Figure 4-2. Set the output of both signal generators at -24 dBm, and the frequency at 500 MHz.

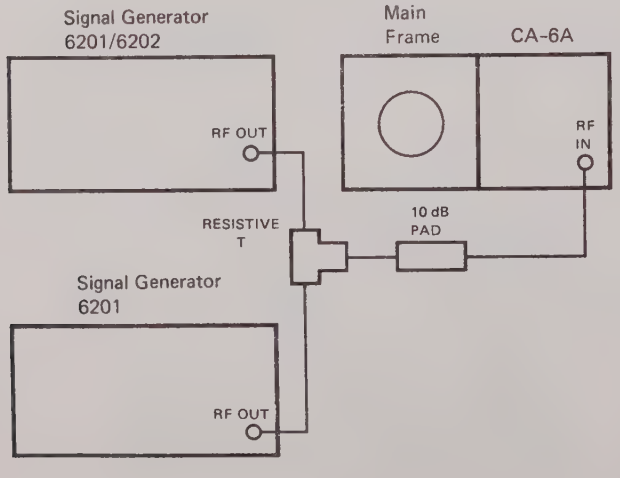


Figure 4-2. Performance Test Setup No. 2

b. Set the SCAN WIDTH/DIV to 30, the BANDWIDTH kHz to 2, the IF GAIN to LOG 20, and IF GAIN/VARIABLE to CAL.

c. Adjust the signal generators so the signals are displayed two divisions apart. The amplitude of both signals should be full-scale on the LOG display; adjust the signal generator output levels as necessary, but not to exceed -40 dBm at the CA-6A RF INPUT.

d. Note any intermodulation (IM) responses two divisions to the right and left of the main responses, respectively.

e. The level of the larger of the IM responses should be more than 60 dB down from the main responses.

4-14. 100 MHz CALIBRATOR ACCURACY (AMPLITUDE).

a. Disconnect one signal generator and connect the CA-6A 100 MHz CALIBRATOR output to the resistive T in its place.

b. Set the CA-6A controls as follows:

CENTER FREQUENCY 100
IF GAIN ..... LIN
IF GAIN/VAR ..... Fully ccw
-40 dBm ..... Depress

Center the 100 MHz calibrator signal, and phase lock the display.

c. Adjust the signal generator frequency until the two signals are two divisions apart. Then adjust the signal generator output level so that both signals are equal in amplitude.

d. The signal generator output level should be -40 dBm ± 0.25 dB.

4-15. 100 MHz CALIBRATOR ACCURACY (FREQUENCY).

Adjust the signal generator frequency so that the two signals are superimposed (beat note). Note the signal generator frequency. It should be 100 ± 0.05 MHz.

4-16. RF ATTENUATOR.

a. Reconnect the signal generator to the CA-6A RF input, as shown in Figure 4-1. Do not connect a modulating oscillator. Set the external attenuators to 40 dB, and adjust the signal generator output level for a full-scale LIN display (1.0 in the LIN scale).

b. Set the CA-6A RF ATTENUATION dB selector to 10.

c. Set the external attenuators for a full-scale LIN display. Note the external attenuator setting. It should be 10 ± 1 dB.

d. Repeat Steps b. and c. for each position of the RF ATTENUATION dB selector as indicated in the table below.

RF ATTENUATION dB	External Attenuation (dB)
20	20 ± 1
30	10 ± 1
40	0 ± 1

e. Set the external attenuation to zero.

4-17. INCIDENTAL FM.

a. Disconnect the signal generator, and connect a comb generator to the CA-6A RF INPUT.

b. Set the CA-6A RF ATTENUATION dB selector to 0. Adjust the comb generator output level for a full-scale LIN display.

c. Release the phase lock pushbutton.

d. Note the incidental FM, which appears as jitter in the display. It should be less than 30 kHz, peak-to-peak.

e. Depress the phase lock pushbutton and phase lock the display. Set the CA-6A controls as follows:

SCAN WIDTH/DIV	.3
BANDWIDTH kHz	.2

f. Note the incidental FM. It should be less than 150 Hz, maximum, peak-to-peak.

g. Set the CA-6A controls as follows:

SCAN WIDTH/DIV	30
BANDWIDTH kHz	5
Phase Lock Pushbutton	Release

h. Set the CENTER FREQUENCY to 500 MHz. Center the signal on the display.

i. Note the incidental FM. It should be less than 30 kHz, peak-to-peak.

j. Repeat Steps e. and f.; center the signal as necessary. Note the incidental FM; it should be less than 150 Hz, maximum, peak-to-peak.

k. Repeat Step g.

l. Set the CENTER FREQUENCY to 1000 MHz. Center the signal on the display. Wait 2 minutes, for minimum drift.

m. Repeat Step i.

n. Repeat Steps e. and f. Center the display, as necessary.

o. Release the phase lock pushbutton.

4-18. SWEEP TIME ACCURACY.

a. Connect the time mark generator as shown in Figure 4-3. Set the time mark generator to 5 mS, and the trigger output to 10 mS.

b. Set the CA-6A controls as follows:

SYNC EXT	Depress
SWEEP mS/DIV	3

For the SMF-6 main frame, it may be convenient to use the variable persistence display.

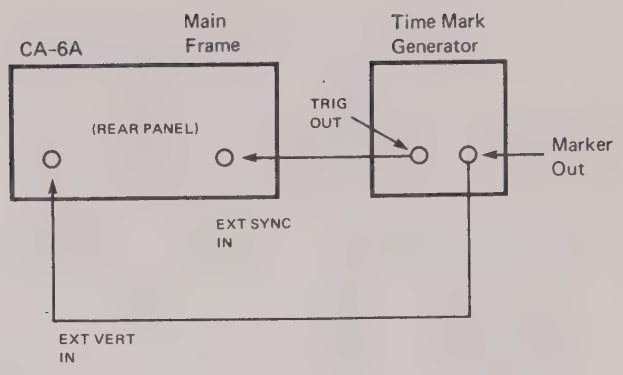


Figure 4-3. Performance Test Setup No. 3

c. Measure the time for one sweep. It should be 30 ± 3 mS.

d. Set the SWEEP mS/DIV to 10, and measure one sweep. It should be 100 ± 10 mS.

e. Set the SWEEP mS/DIV to 30.

f. Set the time mark generator to 50 mS. Set the trigger output to .1 s.

g. Measure the time for one sweep. It should be 300 ± 30 mS.

h. Set the SWEEP mS/DIV to 100, and the time mark generator to .1 s.

i. Measure one sweep. It should be 1000 ± 100 mS.

j. Set the SWEEP mS/DIV to 300.

k. Set the time mark generator to .5 s. Set the trigger output to 1 s.

l. Measure the time for one sweep. It should be 3 ± .3 seconds.

m. Set the SWEEP mS/DIV to 1000, and measure one sweep. It should be 10 ± 1 seconds.

n. Set the SWEEP mS/DIV VERNIER fully counter-clockwise, and measure the time for one sweep. It should be about 33 seconds.

o. Disconnect the time mark generator.

4-19. FREQUENCY RESPONSE.

a. Set up the test equipment as shown in Figure 4-4.

b. Set the CA-6A controls as follows:

RF ATTENUATION dB	10
MULTIPLIER MHz	Depress
SCAN WIDTH/DIV	3
SWEEP mS/DIV	3
SWEEP mS/DIV VERNIER	CAL (Max CW)
SWEEP INT	Depress
BANDWIDTH kHz	20

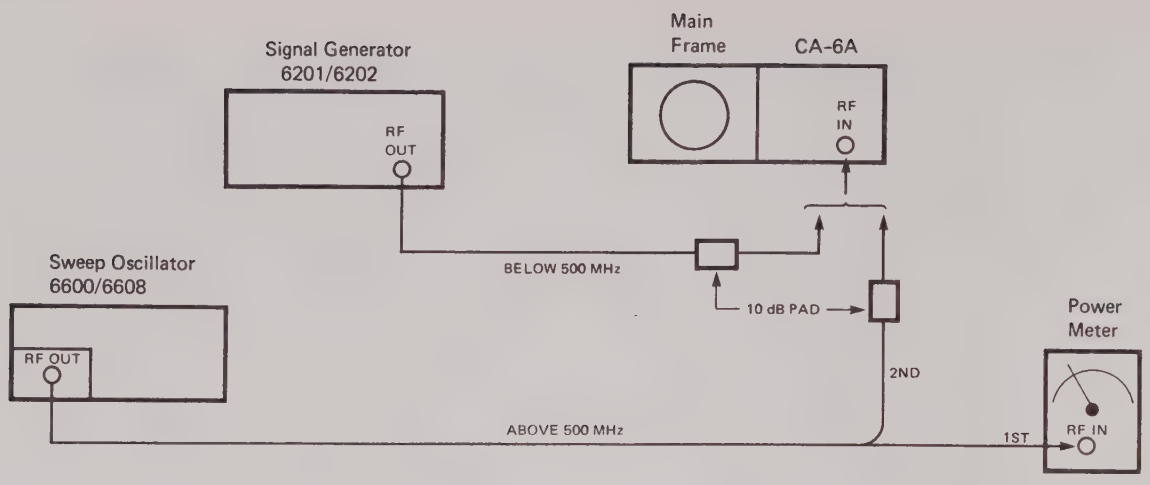


Figure 4-4. Performance Test Setup No. 4

VAR/VIDEO FILTER..... CW
IF GAIN ..... LOG 0

Set the CENTER FREQUENCY so the zero signal is at the left edge of the graticule.

c. Set the signal generator output mode to CW and the frequency to 500 kHz. Adjust the generator output level to 20 dB on the display.

d. Increase the signal generator frequency slowly to 30 MHz. Monitor the generator output level, and the peak-to-peak amplitude deviation on the CRT display. The maximum deviation on the display should be $\leq \pm$ 2 dB.

e. Set the SCAN WIDTH/DIV to 130 and the BANDWIDTH kHz to 200. Set the CENTER FREQUENCY so the zero signal is at the left edge of the graticule. Adjust the signal generator output level to 20 dB on the display. Continue scanning to 512 MHz.

f. To measure frequency response from 500 to 1300 MHz, use a Singer Model 6600 sweep oscillator with the 6608 plug-in, in CW mode. Use a power meter to monitor the sweep oscillator power level variations over the band. Subtract the power level fluctuations measured by the power meter from spectrum analyzer response, to normalize the analyzer frequency response. Set the oscillator output level to 20 dB on the display. Slowly increase the sweep oscillator frequency from 500 to 1300 MHz, and monitor the peak-to-peak amplitude deviation. Amplitude deviation on the display should be $\leq \pm$ 2 dB.

4-20. RESIDUAL RESPONSES (6 - 1300 MHz).

a. Disconnect all test equipment from the CA-6A.

b. Set the CA-6A controls as follows:

IF GAIN..... LIN
RF ATTENUATION dB 20
VAR/VIDEO FILTER..... Fully ccw
SCAN WIDTH/DIV..... 130
MULTIPLIER KHz ..... Depress
BANDWIDTH kHz 200

Set the IF GAIN/VAR control so the baseline coincides with 0.6 on the LIN scale.

c. Very slowly, tune the CENTER FREQUENCY dial between 6 MHz and 1300 MHz and note any responses on the screen. Determine the level of the responses by substitution with an external signal generator.

d. Residual responses should be -100 dBm, or less.

4-21. ALIGNMENT PROCEDURES.

4-22. GENERAL.

4-23. For access to the interior of the instrument, remove the CA-6A and connect it to the main frame with an extender cable. Remove the dust covers from the CA-6A and the appropriate assemblies.

4-24. Figures 4-8 and 4-9 show the location of major assemblies. Figures 4-8 through 4-13 show circuits and components, with appropriate identification for repair or alignment. For access to the interior, it may be necessary to remove one or more of the assemblies. See Paragraph 4-49.

4-25. ALIGNMENT TEST EQUIPMENT LIST.

Sampling Voltmeter	HP Model 3406A
RF Power Meter	HP Model 432A
Spectrum Analyzer	Singer SPA-3000
Comb Generator	HP Model 8406A
Audio Oscillator	HP Model 209A
Sweep Oscillator	Singer 6600 with 6608 Plug-in
Voltmeter	HP Model 427A
Frequency Counter	Eldorado 1650
Signal Generator	Singer SG-1000 and SG-1001 Range Extender
Step Attenuators	HP 355C and 355D
Oscilloscope	HP 1200 Series
Dummy Crystal Mount	Type HC-6/U
Extender Board	Singer Part No. 102-0089-002
Extender Cable	Singer Part No. 556161-661
Non-metallic Tuning Tool	

4-26. FRONT PANEL ASSEMBLY.

4-27. The front panel assembly consists of the RF attenuator AT1 and the 17.0 MHz pulled oscillator A4. Attenuator AT1 is an integral unit that requires no periodic adjustment. The 17.0 MHz pulled oscillator is part of the phase-lock loop, and its alignment is treated in that section. See Paragraph 4-45.

4-28. TRAY ASSEMBLY A1.

4-29. The following assemblies are adjusted and locked at the factory, and do not require periodic adjustment or alignment.

First Mixer	A1A2
1.5 GHz bandpass filter	A1FL2
2 GHz low pass filter	A1FL3
1.44 GHz bandpass filter	A1FL4
1.3 GHz low pass filter	A1FL5
1.5 GHz high pass filter	A1FL1
Phase-lock mixer	A1A4
First Local Oscillator	A1A1
10 dB Attenuator	A1AT1
3 dB Attenuator	A1AT2

4-30. 100 MHz CALIBRATOR A1A3.

4-31. GENERAL.

Except for the 140 dBm amplitude CAL adjust A1A3R4, the calibrator should not require adjustment unless a defective component is replaced. A1A3 is located at the center on the bottom of tray assembly A1. A1A3R4 can be adjusted without disassembling the CA-6A. For the other adjustments, the tray assembly must be removed, and the cover removed from the calibrator assembly. If a defective component has been replaced refer to Paragraph 4-33; DO NOT REASSEMBLE until all adjustments are complete.

4-32. To calibrate the output level, measure the 100 MHz calibrator output level with an HP Model 3406A sampling voltmeter. Adjust A1A3R4 so that the output level is -40 dBm ± .25 dB. A1A3R4 is accessable from the right side of the CA-6A, immediately behind A1FL4. See Figure 4-11 for location.

4-33. 100 MHz ADJUSTMENT.

If any components have been replaced, use the following procedure.

a. With the covers off, connect the 100 MHz calibrator to the tray assembly. Turn ON the main frame power.

b. Set the controls on a Singer SPA-3000 spectrum analyzer as follows:

FREQ DISPERSION	10 MHz/DIV
MHz/DIV	Depress
BANDWIDTH kHz	1000
RANGE	.01 - 3.5
SIGNAL FREQUENCY TUNING	100 MHz
RF ATTENUATOR dB	10
AMPLITUDE SCALE	LIN

c. Connect the calibrator output A1A3J1 to the SPA-3000 spectrum analyzer RF INPUT with a Sealectro-to-TNC cable.

d. Turn ON the main frame power, and depress the -40 dBm pushbutton on the CA-6A. Measure the peak amplitude of the marker signal on the SPA-3000.

e. If necessary, set -40 dBm CAL adjust A1A3R4 to mid-range. Adjust trimmer capacitors A1A3C2 and A1A3C6 for maximum signal amplitude. Then, adjust A1A3R4 for about -40 dBm signal amplitude on the SPA-3000.

f. Depress the CA-6A MARKER pushbutton and reset the SPA-3000 variable frequency dispersion controls so the display shows 13 markers, with the zero pip at the left of the screen.

g. Set the marker amplitude ADJ A1A3R3, and capacitors A1A3C5 and A1A3C7 so that the markers are discernible and the amplitude is as flat as possible. Then, readjust A1A3R3 so that the markers are above the 30 dB line on the LOG scale. Typical marker levels are shown in Figure 2-2.

h. Disconnect the test equipment, and mount the calibrator (with covers) on the tray assembly A1. Connect W4 to A1A3J1.

i. Calibrate the power output as outlined in Paragraph 4-32.

j. Disconnect and reassemble.

4-34. FRONT HOUSING ASSEMBLY A2.

4-35. For access to the top side of A2, remove A2 from the chassis, but do not disconnect the power supply wiring. Remove the dust covers. See Paragraph 4-51 for front housing disassembly instructions. NOTE: Be sure to align the front housing in the sequence given.

4-36. 1.44 GHz SECOND LOCAL OSCILLATOR A2A2.

a. Disconnect cable W12 from the output of the 1.44 GHz bandpass filter A1FL4. See Figure 4-11.

b. Make a pickup loop as follows:

1. Fit a 1-inch piece of solid copper wire into one end of a female-to-female type N connector.

2. Connect the wire/connector assemble to a coaxial cable with type N connectors at each end. Connect the cable to the SPA-3000.

c. Set the SPA-3000 controls as follows:

SIGNAL FREQUENCY	120 MHz
RF ATTENUATOR dB	20
FREQUENCY DISPERSION	100
MHz/DIV Pushbutton	Depress

d. Place the pickup loop near transformer A2A2T1 on the 1.44 GHz oscillator board. Adjust capacitor A2A2C3 for peak signal amplitude at 120 MHz. See Figure 4-10.

e. Set the SPA-3000 controls as follows:

SIGNAL FREQUENCY	240 MHz
RF ATTENUATOR dB	30
FREQUENCY DISPERSION	10
MHz/DIV pushbutton	Depress

f. Place the pickup loop at the output of transformer A2A2T1 at the junction of A2A2L9 and A2A2R12. Tune capacitor A2A2C14 for a clean, maximum, amplitude signal, at 240 MHz.

g. Tune capacitor A2A2C15 to maximize the 240 MHz signal, without parametric spurious responses.

h. Place the pickup loop at the power amplifier output (lead from A2A2R14) and adjust capacitor A2A2C19 for maximum signal amplitude at 240 MHz, without distortion or spurious responses.

i. Disconnect the pickup loop and cable from the SPA-3000. Connect a cable from bandpass filter A1FL4 to the SPA-3000. Use Sealectro-to-TNC adapter. See Figure 4-11.

j. Set the SPA-3000 spectrum analyzer as follows:

SIGNAL FREQUENCY	1.44 GHz
BANDWIDTH kHz	1000
FREQUENCY DISPERSION	100
MHz/DIV Pushbutton	Depress

k. Adjust capacitors A2A2C23 and A2A2C24 for maximum signal amplitude at 1.44 GHz, with no distortion.

l. Check the output level from the 1.44 GHz bandpass filter with an RF power meter. The output level should be at least -10 dBm.

4-37. 60 MHz IF STRIP.

This section covers the 60 MHz IF strip alignment, including the 60 MHz pre-amplifier assembly A2A1A1, the 60 MHz narrow-band filter assembly A2A3, and the 60 MHz IF amplifier assembly A2A4. Be sure to align each assembly in the sequence given in the following procedure.

a. Disconnect W19 (Figure 4-9) from A2J1, and the TNC T connector (A2A1CP2) from the input of A2A1. (See Figure 4-10.) Connect the test equipment as shown in Figure 4-5a. Set the sweep oscillator output to minimum before connecting it to the input of the 60 MHz pre-amplifier.

b. Set the sweep oscillator center frequency to 60 MHz, and the sweep width to 10 MHz (± 5 MHz). Set the external attenuators to 0, and adjust the sweeper RF output level for a convenient full-scale display on the oscilloscope. The sweep oscillator RF output level should be about -30 to -40 dBm.

c. Adjust A2A1A1C4 for maximum amplitude, and best symmetry. Stage gain should be about 8 dB.

d. Disconnect the cable at A2J1, and reconnect W19. Disconnect W22 at A2J3 (Figure 4-9), and connect the step attenuator at A2J3. See Figure 4-5b.

e. Readjust the oscilloscope for a convenient display.

f. Tune A2A3T1, A2A3T2, A2A3L1, and A2A3L2 for maximum response and best symmetry at 60 MHz. The bandwidth should be $\geq$ 2 MHz at 3 dB down, centered at 60 MHz.

g. Disconnect the output of the narrow-band filter assembly from the test setup, and reconnect cable W22.

h. Disconnect cable W25 (Figure 4-8) from A2J5, and connect the output of the 60 MHz IF amplifier assembly to the test setup, as shown in Figure 4-5.

i. Set the gain potentiometer A2A4R11 mid-range.

j. Adjust tuning coils A2A4L2, A2A4L4, and A2A4L6 for best response symmetry, while maintaining the 3 dB bandwidth at 2 MHz, or greater.

k. Vary the CA-6A front panel IF GAIN/VAR control from CAL to the MIN position, and readjust the tuning coils (A2A4L2, A2A4L4, and A2A4L6) for best overall symmetry throughout the range of the IF GAIN/VAR control.

l. Set the IF GAIN/VAR control fully clockwise to CAL. Repeat Step k. for each of the LOG positions (LOG 0 through LOG 30) of the IF GAIN selector (i.e., all positions of the IF GAIN selector, excluding LIN). This will require some compromise in setting the three amplifier tuning coils. Vary the input attenuation (RF ATTENUATION dB) as necessary for the best scope display.

m. Disconnect the CA-6A from the test setup, and reconnect W25 at A2J5, and the input to the second mixer at A1CP2 (Figure 4-11).

n. Replace the dust cover on assembly A2, and temporarily replace the other dust covers on the exterior of the CA-6A.

o. Connect a signal generator to the RF input. Set the frequency to 100 MHz.

p. Set the CA-6A controls as follows:

SCAN WIDTH/DIV	130
MULTIPLIER KHz	Depress
BANDWIDTH kHz	20
VAR/VIDEO FILTER	Fully clockwise
SWEEP mS/DIV	3
SWEEP INT	Depress
IF GAIN	LOG 30
IF GAIN/VAR	CAL
CENTER FREQUENCY	100
RF ATTENUATOR dB	0

Set the CENTER FREQUENCY and the CENTER FREQUENCY FINE TUNING so that the 100 MHz signal is centered at f_o.

q. Set the signal generator output level for a full-scale log display.

r. Set the IF GAIN to LOG 20.

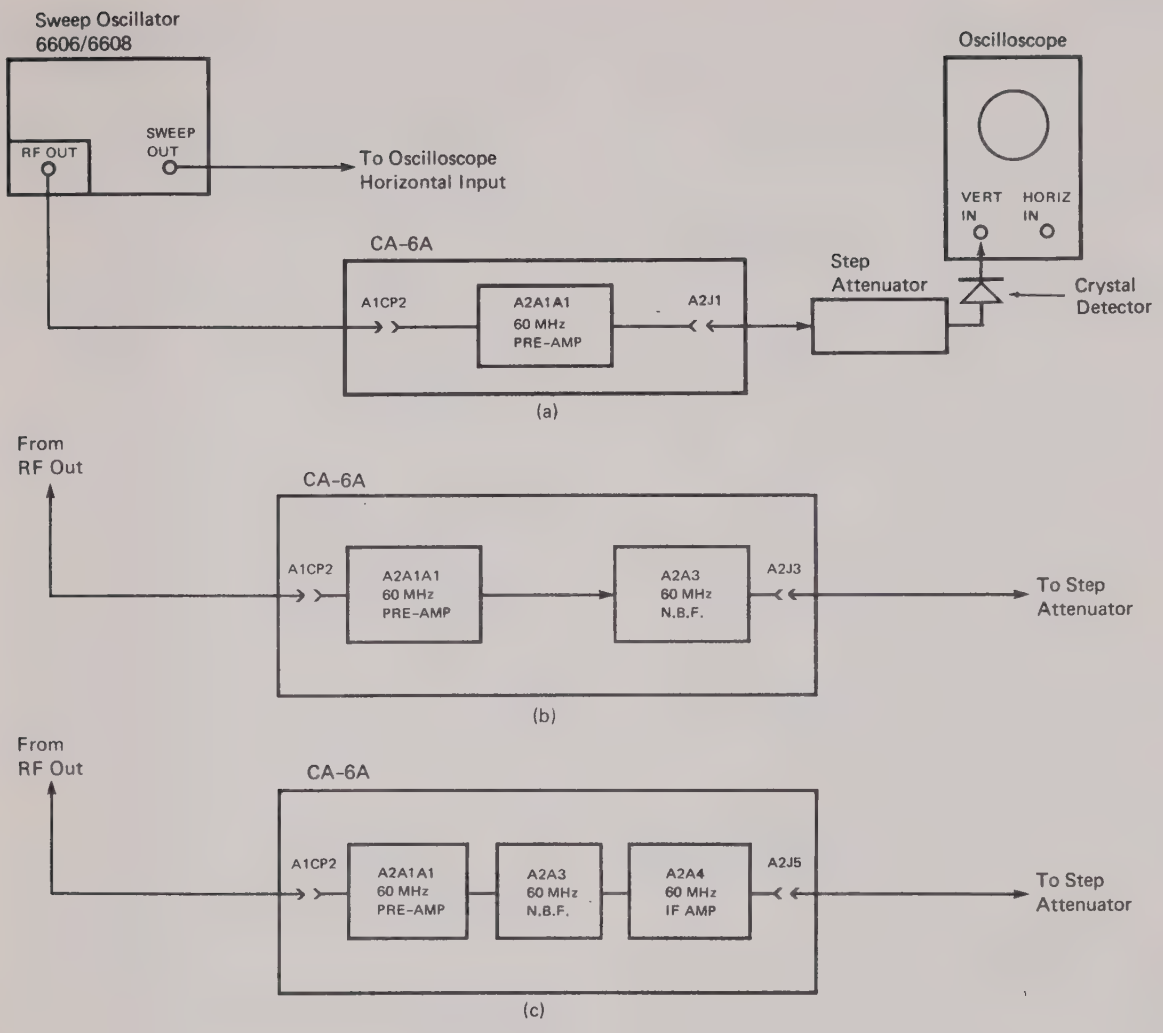


Figure 4-5. Second IF Alignment Setup

s. Adjust the LOG 20 adjust (R40, 1kΩ) for -10 dB display. See Figure 4-13.

t. Set the IF GAIN to LOG 10.

u. Set the LOG 10 adjust (R41, 500Ω) for -20 dB signal display.

v. Set the IF GAIN to LOG 0.

w. Set the LOG 0 adjust (R42, 100Ω) for -30 dB signal display.

x. Disconnect the signal generator, and connect the CA-6A 100 MHz CALIBRATOR output to the CA-6A RF INPUT. Depress the -40 dBm pushbutton, and set the IF GAIN to LOG 10, and the RF ATTENUATION dB to 0.

y. With a screwdriver, turn the front panel AMPLITUDE SCALE CAL adjust fully counterclockwise. Then turn it clockwise for maximum signal amplitude. Finally, turn the CAL adjust counterclockwise until the signal just begins to decrease.

z. Adjust potentiometer A2A4R11 (on the 60 MHz IF amplifier) for exactly full-scale signal. This results in best signal to noise ratio.

NOTE

If there are spikes on the display, the 60 MHz amplifier is oscillating. Increase the 60 MHz GAIN adjust A2A4R11 until the spikes disappear. Then, set the front panel amplitude scale CAL adjust for a full-scale signal display.

4-38. REAR HOUSING ASSEMBLY A3.

Use a properly adjusted MF-6A or SMF-6A main frame for the CRT display while testing and aligning the subassemblies in A3. Depress the CA-6A LINE CAL pushbutton, and adjust the V POS and V CAL so that the signal displayed occupies the lower 5 divisions on the display.

NOTE

Align the rear housing assembly (A3) in the following sequence.

4-39. LIN/LOG AMPLIFIER A3A4.

a. Disconnect W28, and connect a signal generator to A3A4J3. See Figures 4-8 and 4-12. Set the signal generator output to 2.7 MHz at +10 dBm.

b. Set the CA-6A front panel AMPLITUDE SCALE selector to LOG 0. Depress the SWEEP INT pushbutton.

c. Set all trimmer capacitors for minimum capacitance.

NOTE

Trimmer capacitor adjustment has relatively little effect on output signal amplitude. If desired, they may be adjusted for maximum signal output.

d. Adjust potentiometer A3A4R47 so the trace extends about one division above the 0 dB graticule line.

e. Adjust the output of the signal generator until the trace coincides with the 60 dB graticule line.

f. Then increase the output level by 60 dB. Readjust A3A4R47 so that the trace coincides with the 0 dB graticule line.

g. Reduce the signal generator output in 10 dB increments; the trace should coincide with the respective graticule lines. If it does not, repeat Steps d. through f. until it does.

h. Set the AMPLITUDE SCALE switch to LIN. Set the signal generator output to -40 dBm.

i. Adjust A3A4C58 for maximum vertical trace deflection.

j. Adjust A3A4R59 so that the peak of the trace is at 1.0 line on the LIN scale.

k. Reduce the signal generator output level to -50 dBm. The trace should be at .3 on the LIN scale.

l. If it is not, adjust the signal generator output level to position the trace at the .3 graticule line. Then increase the output level 10 dB and readjust A3A4R59 so that the trace coincides with the 1.0 graticule line. Repeat until conditions are met. Disconnect the signal generator and reconnect W28.

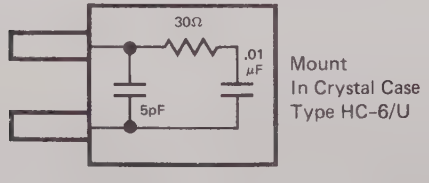


Figure 4-6. Variable Bandwidth Amplifier R-C Test Network

4-40. THIRD LOCAL OSCILLATOR A3A1 (PRELIMINARY).

a. Disconnect cable W25. Connect a signal generator to furnish the IF input to A3J1. (See Figure 4-9.)

b. Set the CA-6A controls as follows:

IF GAIN	LOG (any position)
BANDWIDTH kHz	200
VAR/VIDEO FILTER	MAX BW (fully cw)
SCAN WIDTH/DIV	130
SCAN WIDTH/DIV VARIABLE	CAL (fully cw)
MULTIPLIER KHz	Depress

c. Set the signal generator output level to -50 dBm at 60 MHz.

d. Adjust the main frame controls for a convenient display and tune the signal generator from 50 to 70 MHz. There should be two responses, 5.4 MHz apart.

e. Tune the signal generator to 60 MHz. Adjust A3A1L5 so that the higher frequency response is centered on the display at f_o when the signal generator is tuned to 60 MHz.

f. Set the signal generator frequency to 54.6 MHz, and check for the presence of an image response on the display.

4-41. VARIABLE BANDWIDTH AMPLIFIER A3A3.

a. Disconnect W27. (See Figure 4-9.) Remove the narrow-band filter assembly A3A2 from the casting. Connect a jumper cable from the output of the third LO (A3A1J3) to the pin at the other end of the casting that houses A3A2.

b. Connect a signal generator to A3J1 (at the input to the third mixer) to furnish the IF input. Set the signal generator for 60 MHz at about -30 dBm.

c. Set the CA-6A controls as follows:

BANDWIDTH kHz	VAR
SCAN WIDTH/DIV	30
MULTIPLIER KHz	Depress

d. Cover the LOG/LIN amplifier with a cover plate.

e. Set A3A3R12 and A3A3R30 at mid-range. (See Figure 4-8.)

f. Remove crystal A3A3Y1. Connect an R-C network and install it in place of Y1. The substitute circuit is shown in Figure 4-6.

g. Turn the VAR/VIDEO FILTER control fully counterclockwise. Adjust A3A3C20 until a narrow response appears on the display.

h. Turn the VAR/VIDEO FILTER control fully clockwise. Adjust A3A3L7 for maximum bandwidth of the main response.

i. Turn the VAR/VIDEO FILTER control counterclockwise until the bandwidth is reduced significantly--about 50%.

j. Adjust A3A3C20 so that the response at the 30 dB point is symmetrical.

k. Rotate the VAR/VIDEO FILTER control to MAX BW. Adjust A3A3L7 for maximum bandwidth of the main response.

l. Adjust A3A3C21 for maximum trough, between the main response, and the nearest spurious response.

m. Set the IF GAIN selector to LIN. Adjust the signal generator for a full-scale LIN display.

n. Adjust A3A3R30 so the 3 dB bandwidth of the response is 30 kHz.

o. If necessary, readjust A3A3L7 for a smooth, symmetrical response.

p. Replace crystal A3A3Y1. Remove A3A3Y2, and install the R-C network in its place.

q. Set the IF GAIN selector to one of the LOG positions. Repeat Steps g. through p. to align the second filter section by adjusting A3A3C6, A3A3L3, and A3A3C7, respectively.

r. Reinstall crystal A3A3Y2 and adjust A3A3C17 for maximum amplitude response.

s. Install narrow-band filter A3A2 and reconnect W27.

4-42. 2.7 MHz NARROW-BAND FILTER A3A2.

a. Set the CA-6A controls as follows:

IF GAIN..... any LOG position
BANDWIDTH kHz 20
MULTIPLIER KHz..... Depress

b. Set the signal generator output level for a full-scale LOG display.

c. Adjust capacitors A3A2C8, A3A2C10, A3A2C13, and A3A2C16 for maximum response and good symmetry down to the 60 dB point. There should be no spurious responses in the display.

4-43. THIRD LOCAL OSCILLATOR A3A1 (FINAL ALIGNMENT).

a. Set the CA-6A controls as follows:

SCAN WIDTH/DIV..... 130
MULTIPLIER KHz ..... Depress
BANDWIDTH kHz 10
CENTER FREQUENCY FINE
TUNING ..... Mid-range

b. Adjust A3A1R3 for the maximum signal width.

c. Connect an audio oscillator to amplitude modulate the signal generator. Set the modulating frequency at 130 kHz.

d. Adjust A3A1R7 to center the useful portion of the display. Adjust the signal generator frequency as necessary to center the display.

e. Alternately adjust A3A1R12 and A3A1R13 for a linear sweep. There should be one sideband at each division on the graticule.

f. Adjust A3A1R7 and/or the signal generator frequency to recenter the display.

g. Adjust A3A1R3 to position the modulation sidebands at the respective graticule lines.

h. Adjust the frequency of the signal generator to 60 MHz.

i. Tune A3A1L5 to center the display.

j. Set the signal generator to 54.6 MHz. There should be a display similar to that obtained in Step h.

k. Set the signal generator to 60 MHz and disconnect the audio oscillator.

l. Tune A3A1C19, A3A1C24, and A3A1C28 for maximum signal response.

m. Set the BANDWIDTH kHz switch to 200.

n. Adjust the signal generator output so that the response peak coincides with the LOG 10 dB graticule line.

o. Set the BANDWIDTH kHz switch to 20.

p. Adjust A3A3R23 (in variable bandwidth amplifier, (Figure 4-8) so that the response peak coincides with the LOG 10 dB graticule line.

q. Disconnect the signal generator, and reconnect the cables.

4-44. SHAPING ASSEMBLY/SWEEP GENERATOR A5.

NOTE

Align assembly A5 in the sequence given.

a. Turn OFF the line power, and remove assembly A5 from its receptacle to disable the horizontal sweep. See Figure 4-8.

b. Turn ON the line power, and center the vertical trace on the f_o graticule line with the main frame H POS adjust. Replace A5.

c. Turn OFF the line power, replace A5, and turn the line power ON.

d. Depress the SWEEP INT pushbutton.

e. Adjust the main frame H CAL adjust so the trace extends 1/2 division past the extreme left of the graticule.

f. Adjust sawtooth balance potentiometer A5R11 to balance the deflection. The trace should extend 1/2 division past the extreme right of the graticule.

g. Set the CA-6A IF GAIN controls so the noise level amplitude is about 2 divisions high.

h. Depress the SYNC INT pushbutton.

i. Adjust A5R23 so the sweep triggers intermittently on the noise level peaks.

j. Depress the SWEEP INT and MULTIPLIER kHz pushbuttons.

k. Check the voltage at the anodes of each shaping diode listed in the following table, adjust the associated potentiometers as necessary. Use an extender board if necessary.

NOTES

Check the cathode voltage of CR6, instead of the anode voltage.

The shaping potentiometers interact; therefore they must be adjusted in the order listed.

BREAKPOINT VOLTAGE SETTINGS*		
Diode	Potentiometer	Breakpoint Voltage
CR6	R43	- .5**
CR7	R46	0
CR8	R49	-1.0
CR9	R52	-2.0
CR10	R55	-2.8
CR11	R58	-3.6
CR12	R61	-4.1
CR13	R64	-4.6
CR14	R67	-5.5
CR15	R70	-5.8

* Prefix diodes and resistors with A5.
**CR6 anode voltage; all others are cathode voltages.

l. Set the SCAN WIDTH/DIV switch to 10 and depress the MULTIPLIER MHz. Adjust the CENTER FREQUENCY control so the 0 pip is centered at f_o on the graticule. If necessary, adjust A5R81 to bring the 0 pip within range.

m. Set the CENTER FREQUENCY so the 0 pip is at the extreme left of the graticule.

n. Connect a comb generator to the RF INPUT and apply a 10 MHz comb. Adjust A5R76 so there are 10 pips on the display.

o. Readjust A5R76 so that the two adjacent pips that are the closest together are separated by one division.

p. Adjust shaping potentiometer A5R43 for best sweep, or scan linearity of comb display.

q. Set the comb generator for a 100 MHz comb. Set the SCAN WIDTH/DIV selector to 130 and the SCAN WIDTH/DIV VARIABLE control so the 0 pip and the 100 MHz pip (first marker) are separated by 1 division.

r. Adjust the CENTER FREQUENCY control so the 0 pip is at the extreme left of the graticule.

s. Adjust the diaplay for scan linearity to 1300 MHz by readjusting the shaping potentiometers so each succeeding comb marker coincides with a graticule division. Do not adjust A5R43. Be sure to adjust the shaping potentiometers in the order listed.

t. Set the SCAN WIDTH/DIV VARIABLE control to CAL. Adjust the CENTER FREQUENCY control so the 0 pip is at the extreme left of the graticule.

u. Alternately adjust A5R76 and the CENTER FREQUENCY control so that there are 13 comb markers in the display, with the 0 pip at the left edge of the graticule, and the 13th at the right edge of the graticule.

v. Set the SCAN WIDTH/DIV selector to 1 and the CENTER FREQUENCY to 100.

w. Adjust A5R81 so the 100 MHz pip is at f_o on the graticule.

x. Set the CENTER FREQUENCY to 0 (at the stops).

y. Adjust A5R43 (first breakpoint) so the 0 pip is at the right edge of the graticule.

z. Set the CENTER FREQUENCY to 1200.

aa. Adjust A5R78 so the 12th marker pip is at f_o on the graticule.

bb. Repeat Steps v. and w.

4-45. PHASE LOCK ALIGNMENT.

NOTE

Align the phase lock system in the sequence given.

4-46. 17.0 MHz PULLED OSCILLATOR A4.

a. Disconnect W8 from A2J8 on the front housing assembly A2. (See Figure 4-9.)

b. Remove the top cover from assembly A4. (See Figure 4-8.)

c. Connect an RF power meter or sampling voltmeter to W8 through a 20 dB pad. Use a Sealectro-to-BNC adapter.

d. Set the front-panel PHASE LOCK ADJUST (variable capacitor) at minimum capacitance.

e. Adjust A4C5 for maximum power output. Power output level should be about 8 to 16 mW.

f. Disconnect the power meter and connect a frequency counter through the 20 dB attenuator.

g. Adjust A4C2 so the output frequency is about 17.012 MHz. Do not change the PHASE LOCK ADJUST.

h. Set the PHASE LOCK ADJUST capacitor at maximum capacitance. The oscillator output frequency should be about 16.920 MHz. Adjust the A4C2 as necessary. The frequency should be tunable over about 80-90 kHz with the PHASE LOCK ADJUST.

i. Check the output power (Step c). If necessary, repeat Step e.

j. Replace the cover on A4, and check power and frequency across the tuning range.

k. Turn the PHASE LOCK ADJUST at minimum frequency, and check the output frequency. If necessary, adjust A4C2 for about 16.920 kHz through the access hole in the cover.

l. Reconnect W8.

4-47. 17.0 MHz POWER AMPLIFIER AND HARMONIC GENERATOR A2A5.

a. All harmonics from A2A5 should be greater than -65 dBm between 1.5 and 2.8 GHz. Establish a -65 dBm reference level, and adjust the analyzer so it scans from 1.5 to 2.8 GHz. If microwave signal generators are not available, use a sweep oscillator (CW mode) to set the scan end points. Set the -65 dBm reference level with a power meter and external attenuators. The SPA-3000 controls should then be set as follows:

RANGE	.01 - 3.5 GHz
SIGNAL FREQUENCY	2.15 GHz
BANDWIDTH	1.3 GHz
FREQUENCY DISPERSION	300 MHz/DIV
RF ATTENUATOR dB	0

b. Disconnect W9 from the 10 dB OSM attenuator A2AT1, which is connected to A2J7. See Figure 4-9.

c. Connect the output of A2A5 (through A2AT1) to the input of the SPA-3000. Use an OSM-to-Type N adapter.

d. Adjust A2A5C3 for maximum harmonic comb amplitude. Mark a reference line along the top of the frequency comb display on the SPA-3000.

e. Disconnect A2A5 from the SPA-3000, and reconnect the signal generator. Set the generator output to -65 dBm, and note that reference level on the SPA-3000. No point on the reference line (drawn in Step d.) should extend below the -65 dBm reference level.

4-48. 11.85 MHz AMPLIFIER/LIMITER A2A6; DETECTOR AND REFERENCE OSCILLATOR A2A7.

CAUTION

DO NOT readjust A2A6 and A2A7 unless one of the adjustable inductors has been replaced, or the phase lock loop is clearly out of adjustment. These adjustments have been set at the factory and should not require adjustment.

a. Disconnect cable W15 from A2A7J2, and W17 from A2A6J2. See Figure 4-9.

b. Connect the equipment as shown in Figure 4-7. Place W16 as close as possible to A2A7T1, to pick up an 11.85 MHz reference signal to aid alignment.

c. Set A2A6L1 and A2A7T1 so the core is flush with the top of the coil assembly.

d. Set the sweep generator center frequency to 11.85 MHz, with about 1 MHz sweep width. Increase the RF output level until a response shows on the oscilloscope. Note an 11.85 MHz "Birdie," or heterodyne signal.

e. Set A2A7T4 and A2A7T5 for maximum "Birdie" response, with best symmetry.

f. Decrease the RF output level until the "Birdie" amplitude starts to decrease (at about -60 dBm). Readjust A2A7T4 and A2A7T5 for best symmetry and maximum amplitude, disregarding flatness. If the loop is functioning properly, response amplitude will remain about the same as input power is varied from -10 dBm to -60 dBm. (Response shape will vary.)

g. Disconnect the test equipment and reconnect W15 and W17.

h. Check phase lock loop operation as follows:

1. Connect the CA-6A 100 MHz CALIBRATOR output to the RF INPUT. Set the CA-6A controls as follows:

SCAN WIDTH/DIV	130
MULTIPLIER KHz	Depress
CENTER FREQUENCY	100
FINE TUNING	Center of Range
MARKER	Depress

2. Center the 100 MHz marker on the display with the CENTER FREQUENCY control. Depress the phase lock pushbutton. Center the 100 MHz marker with the PHASE LOCK ADJUST.

3. One at a time, turn the SCAN WIDTH/DIV, IF GAIN, and BANDWIDTH kHz controls to all positions The marker should remain phase-locked.

4. Repeat Steps 2. and 3. for each marker from 200 MHz to 1300 MHz. If the markers remain locked, the adjustment procedure is complete. If not, continue to Step i.

i. If the unit loses phase lock, it will probably occur from 900 to 1300 MHz. Select the worst case, and phase lock that marker. Turn the control that causes the phase lock drop out (usually the BANDWIDTH kHz). When the phase lock drops out, tune A2A6L1 and/or A2A7T1. The unlocked marker should move toward the center of the screen, and then "jump" into phase lock.

j. Recheck the other markers, and slightly retune A2A6L1 and A2A7T1 for correct lock. If the phase lock loop will not lock at all frequencies, troubleshoot the individual phase lock components.

4-49. DISASSEMBLY PROCEDURES.

4-50. TRAY ASSEMBLY A1.

a. Remove the CA-6A dust covers.

b. Disconnect the cables to the tray assembly.

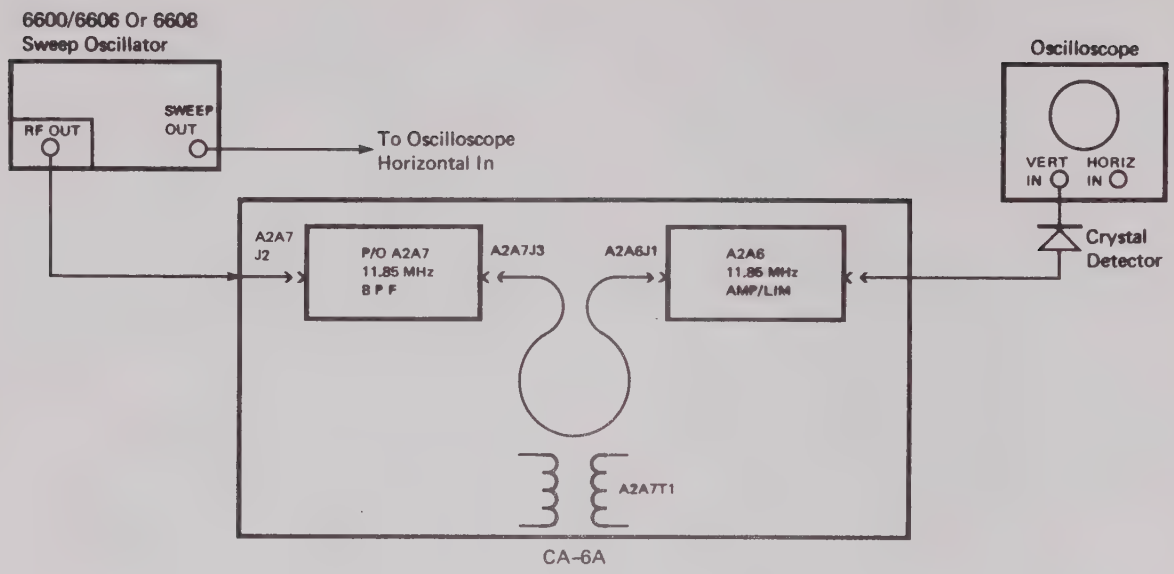


Figure 4-7. A2A6 and A2A7 Alignment Setup

c. Remove the six screws and lockwashers securing the tray to the frame; and the one screw securing the tray to the angle bracket on A4.

d. Disconnect T-adapter A1CP2 from the 60 MHz pre-amplifier A2A1 (input to A2).

e. Carefully lift the tray and disconnect multi-pin connector P3. Remove the tray assembly.

4-51. FRONT HOUSING ASSEMBLY A2.

a. Remove the CA-6A dust covers.

b. Disconnect the cables to the front housing assembly.

c. Remove the eight screws and lockwashers securing A2 to the frame.

d. Disconnect T-adapter A1CP2 from 60 MHz pre-amplifier A2A1 (input to A2).

e. Carefully remove the front housing.

4-52. REAR HOUSING ASSEMBLY A3.

a. Remove the CA-6A dust covers.

b. Disconnect the cables to the rear housing assembly A3J2.

c. Disconnect multi-pin connector P1 from A3.

d. Remove the twelve screws and washers securing the rear housing to the frame, and remove the rear housing.

4-53. RF ATTENUATOR AT1.

a. Remove front housing assembly A2 (Paragraph 4-51).

b. Disconnect cable W3 from RF attenuator AT1.

c. Remove the hexagonal retaining nut securing the RF input connector.

d. Remove the RF ATTENUATION knob.

e. Remove two screws that secure the attenuator housing to the front panel. Slide the attenuator back and remove it.

4-54. 17.0 MHz PULLED OSCILLATOR A4.

a. Remove tray assembly A1 (Paragraph 4-50).

b. Remove cable W8.

c. Unsolder the -12 V and ground wires to A4.

d. Remove the PHASE LOCK ADJUST knob.

e. Remove the hexagonal retaining nut from the PHASE LOCK ADJUST shaft.

f. Slide the pulled oscillator back from front panel and remove.

NOTE

Replace the hexagonal nut on the shaft immediately. It retains the tuning capacitor within A4.

4-55. TROUBLESHOOTING.

4-56. POWER DISTRIBUTION TROUBLES.

4-57. Power for the CA-6A is obtained from the main frame through connector P4. The -5 V supply for the integrated circuits on sweep generator/shaping assembly A5 is developed on A5 from the main frame -12 V supply. See the schematic diagrams (Section V) for power distribution.

WARNING

There are dangerous voltages in the main frame. Always be careful when measuring power supply voltages.

4-58. TROUBLESHOOTING PROCEDURES.

4-59. Locate trouble by either symptomatic or systematic troubleshooting. Symptomatic troubleshooting helps localize a malfunction by noting if operation is normal when a front panel switch is set to one or more positions but not to others. See Table 4-1. If this fails to localize the trouble, use the step-by-step systematic troubleshooting procedures in Table 4-2.

4-60. VOLTAGE MEASUREMENTS.

4-61. The voltage measurements for the active elements within the CA-6A are listed in Tables 4-3 through 4-15. Unless otherwise noted, all measurements were made with a VTVM with respect to chassis ground after the front panel controls were set as indicated below:

CENTER FREQUENCY MHz	650
SCAN WIDTH/DIV.....	130
SCAN WIDTH/DIV VARIABLE ...	CAL (fully cw)
MULTIPLIER MHz	Depress
SWEEP mS/DIV.....	3
SWEEP mS/DIV VERNIER	CAL (fully cw)
IF GAIN.....	LOG 0
IF GAIN VAR.....	CAL (fully cw)
RF ATTENUATION dB.....	10
SWEEP INT	Depress
BANDWIDTH kHz.....	200
VAR/VIDEO FILTER	MAX BW (fully cw)

4-62. COMPONENT LOCATIONS.

4-63. Figures 4-8 through 4-13 show the location of the major assemblies and circuit boards within the major assemblies. For access to subassemblies in the front and rear housings, remove the dust covers as necessary, or disassemble according to the disassembly instructions, Paragraph 4-51.

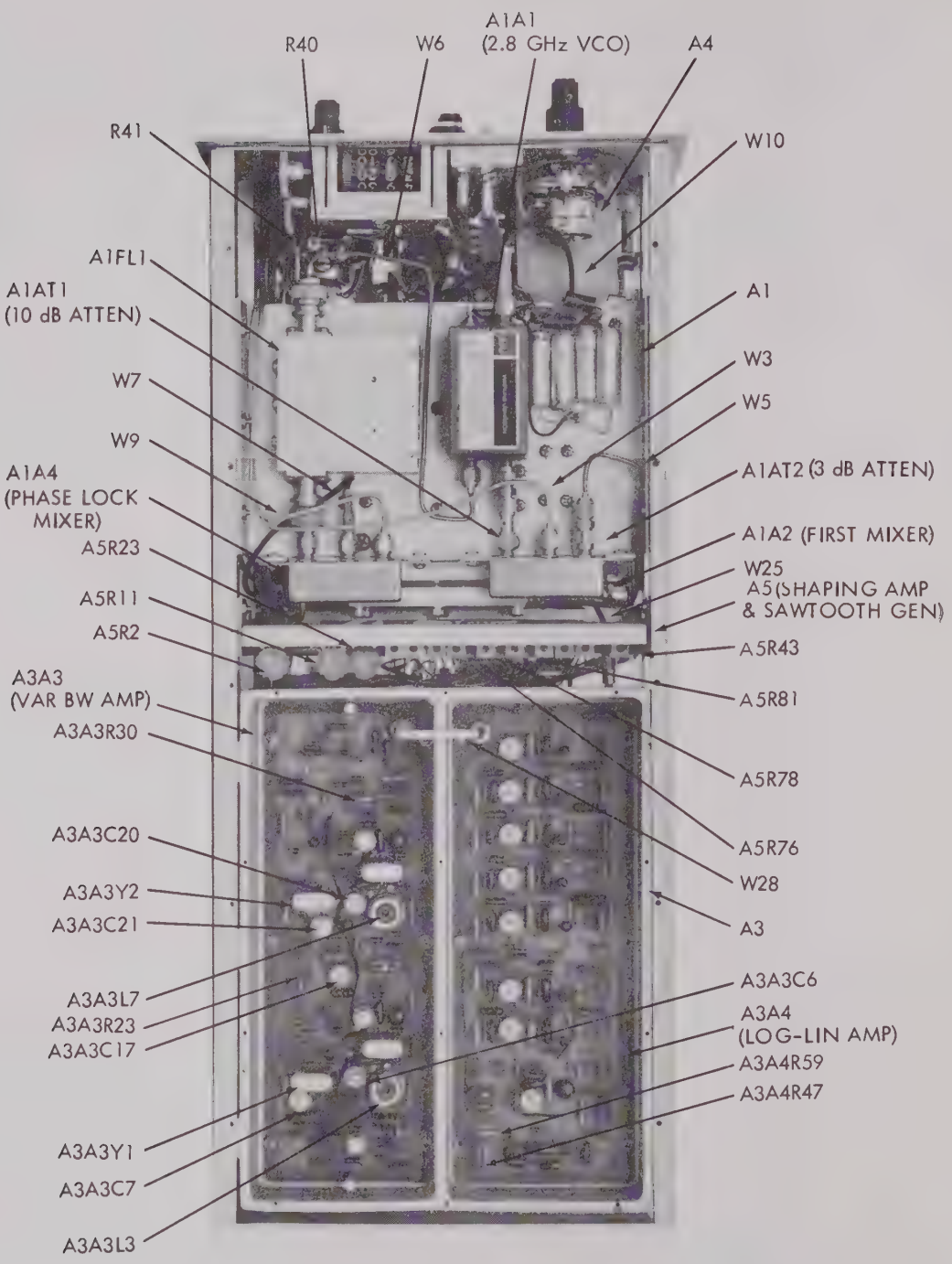


Figure 4-8. CA-6A Top View, Cover Removed

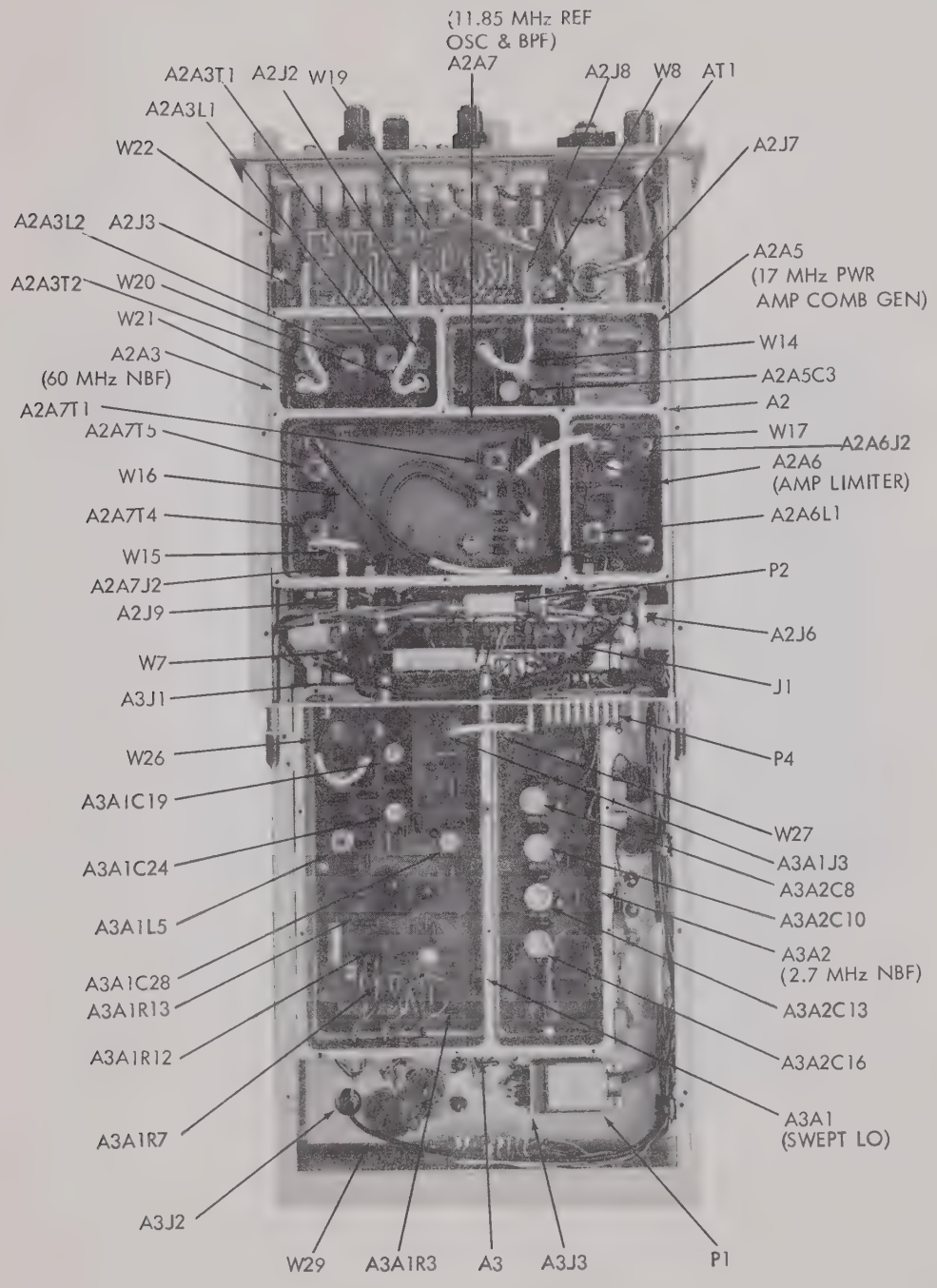


Figure 4-9. CA-6A Bottom View, Cover Removed

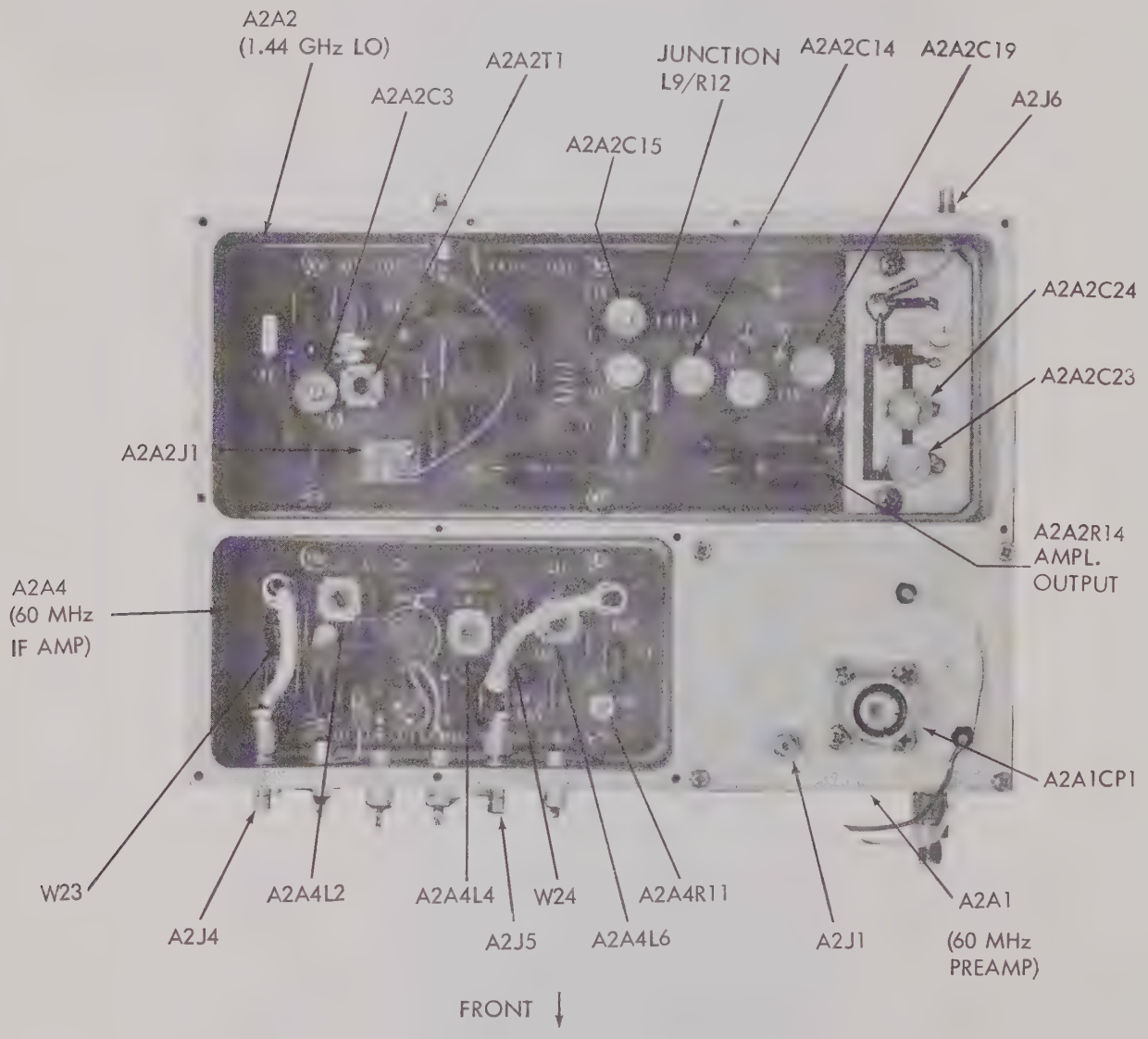


Figure 4-10. CA-6A Front Housing Assembly, Top View

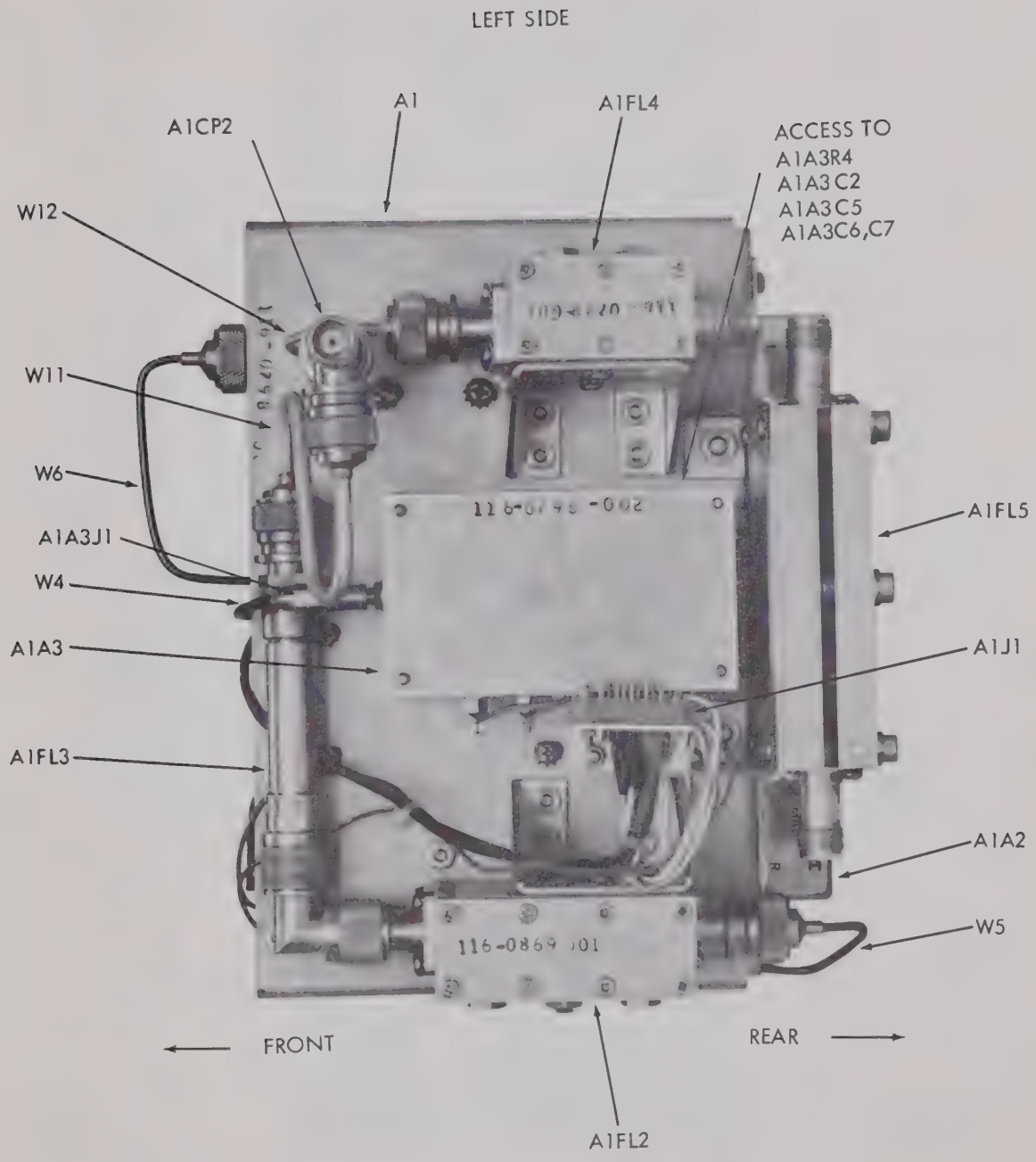


Figure 4-11. CA-6A RF Tray, Bottom View

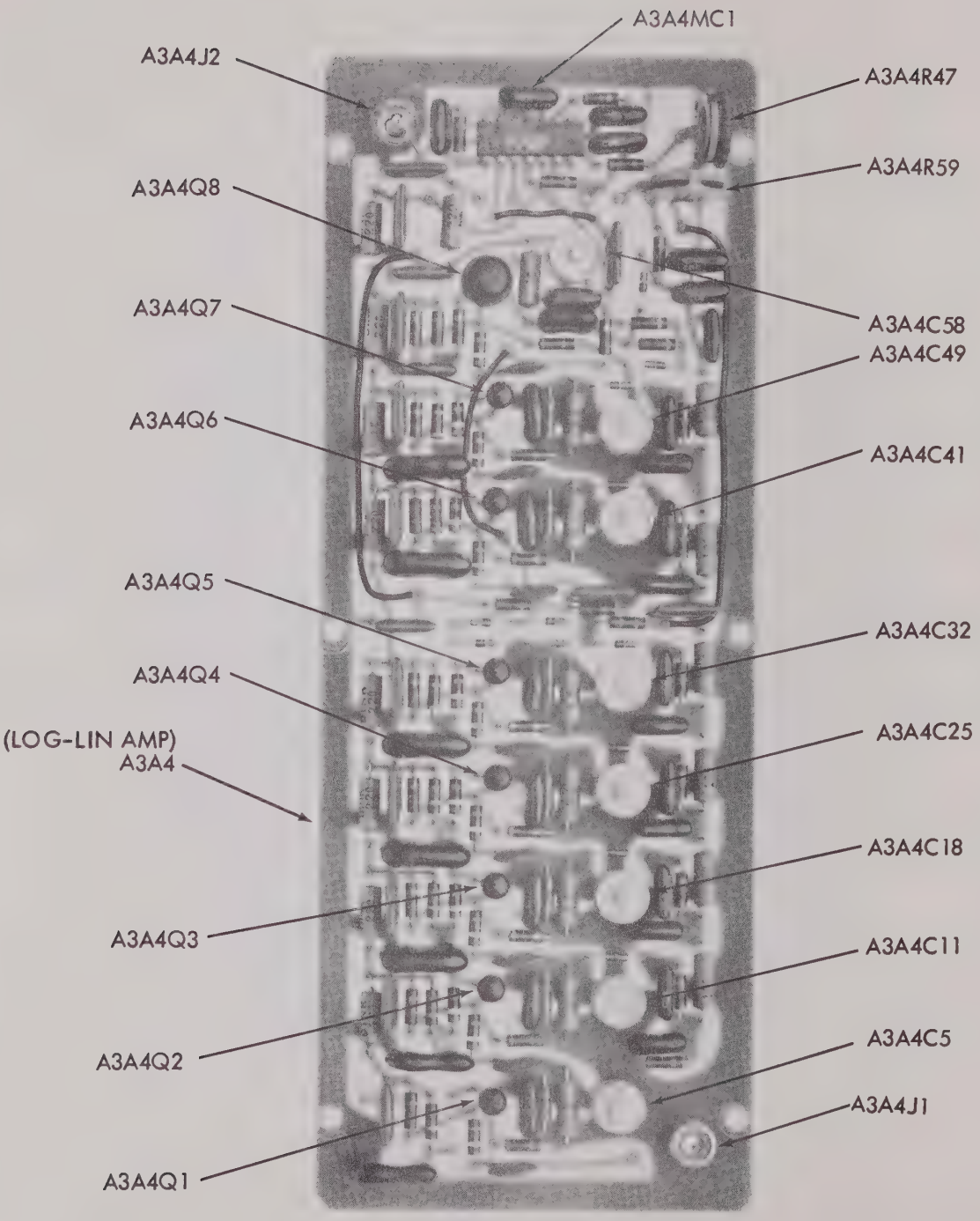


Figure 4-12. CA-6A Log/Lin Amplifier

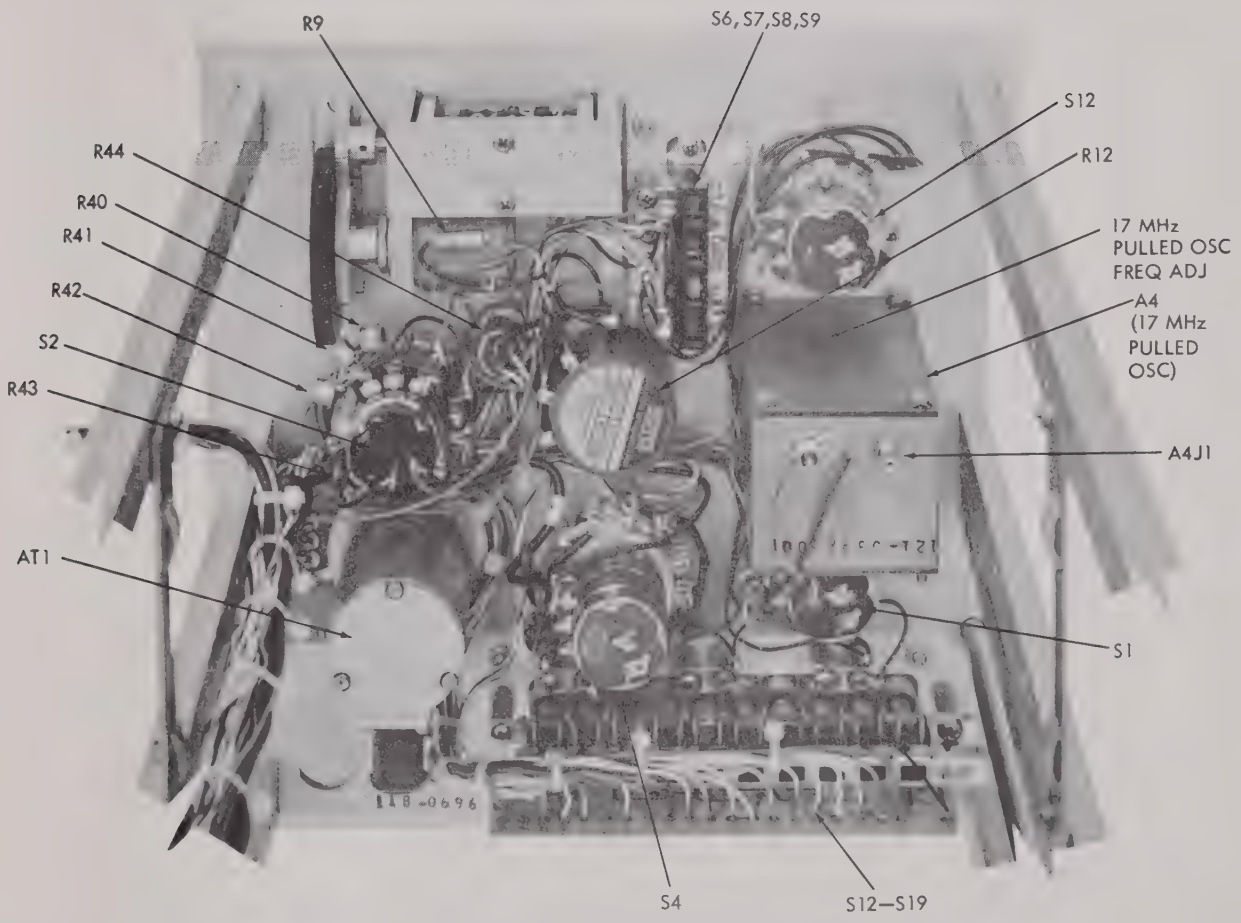


Figure 4-13. CA-6A Inside Cover

TABLE 4-1 SYMPTOMATIC TROUBLESHOOTING PROCEDURE

Symptom	Check
I Horizontal deflection OK, but:	
1. No vertical display for either LIN or LOG.	a. Log/Lin amplifier A3A4 (Table 4-13).
	b. Log/Lin switch circuit.
	c. Signal trace through RF, IF and video detector (see Table 4-2).
2. Narrow scans inoperative; wide scans OK.	a. kHz MULTIPLIER pushbutton circuit.
	b. Sawtooth inverter circuit in A5 (see Table 4-15).
	c. Narrow band swept third local oscillator A3A1 (Paragraph 4-43).
3. Wide scans inoperative; narrow scans normal.	a. MHz MULTIPLIER pushbutton circuit.
	b. Summing/shaping circuits in A5 (Paragraph 4-44, Table 4-15).
	c. Swept first local oscillator A1A1 and attenuator A1AT1.
4. Wide and narrow scans inoperative.	a. Scan width control network and SCAN WIDTH/DIV switch circuit.
	b. CENTER FREQUENCY control circuit.
5. No vertical display when BANDWIDTH switch set for narrow bandwidth or VAR.	a. BANDWIDTH switch circuit.
	b. Diode switches in A3A2 and A3A3.
6. No vertical display when BANDWIDTH switch set for 200 kHz.	a. Diode switches in A3A2 and A3A3.
7. Non-linear marker display in wide scans.	a. Shaping network in A5 (Paragraph 4-44, Table 4-15).
8. No vertical deflection in LINE CAL sync mode.	a. R21.
II Vertical deflection OK, but:	
1. No single sweep; other sweep modes OK.	a. SGL SWEEP pushbutton, R16 and C1.
2. No internal or single sweep; external and manual sweep OK.	a. Sawtooth (sweep) generator circuit (Paragraph 4-44, Table 4-15).
	b. SWEEP mS/DIV switch, voltage divider R1 - R6.
	c. Sweep VERNIER R7 and R8.
3. No external sweep; other sweep modes OK.	a. EXT SWEEP pushbutton S14 and associated circuitry.
4. No manual sweep; other sweep modes OK.	a. Manual control R18, EXT SWEEP and MAN SWEEP pushbuttons S14B and S15B.
5. No sweep in any mode.	a. Logic circuit power supply Q8, Q9 in A5 (see Table 4-15).
	b. Sync and sweep logic in A5 (see Table 4-15).
6. No sweep in sync modes.	a. Sync driver Q7, amplifier A2, Schmitt trigger in A5 (see Table 4-15).
7. No sweep in LINE CAL sync mode.	a. Diode CR1, R20, pushbutton S19.

TABLE 4-1 SYMPTOMATIC TROUBLE SHOOTING PROCEDURE

(CONTINUED)

Symptom	Check
III 100 MHz CALIBRATOR	
1. No output with either -40 dBm or MARKER pushbutton depressed.	a. 100 MHz oscillator A1A3 (see Table 4-7). and output cable to front panel.
2. No 100 MHz marker output; -40 dBm calibrated signal operative.	a. Harmonic generator A1A3 and switching relay.
IV Phase Lock	
1. PHASE LOCK ADJUST inoperative with kHz and LOCK pushbuttons depressed.	a. Phase lock power and switching circuits. b. Signal trace phase lock loop (see also Table 4-2). c. First local oscillator A1A1. d. Input to shaping/summing network in A5.

TABLE 4-2 SYSTEMATIC TROUBLESHOOTING PROCEDURE

PART 1. VERTICAL DEFLECTION TROUBLESHOOTING

Procedure	Normal Indication	If Indication Is normal	If Indication Is Abnormal
1. Set the CA-6A controls as follows: SCAN WIDTH/DIV ..... 130 kHz MULTIPLIER..... Depress BANDWIDTH kHz ..... 200 VAR/VIDEO FILTER ... MAX CW SWEEP mS/DIV ..... 10 INT/SWEEP ..... Depress CENTER FREQUENCY . 0 IF GAIN ..... LOG 30 IF GAIN VAR ..... CAL	Vertical deflection on CRT		Go to Step 2.
2. Observe the P-P noise level on the CRT.	2 div, P-P, variable by adjusting the IF GAIN/VAR control.	Go to Step 7.	a. Noise is about 1/2 div P-P. Go to Step 6. b. No noise. Go to Step 3.
3. Depress LINE CAL pushbutton.	Waveform as shown in Figure 2-3.	Go to Step 5.	Go to Step 4.
4. Check the waveform at P4-9 with an oscilloscope.	1.4 V P-P at 60 Hz.	Troubleshoot the main frame.	Troubleshoot the LOG amplifier output amplifier IC A3A4A1.
5. Depress the SWEEP INT pushbutton. Disconnect W28; connect a 2.7 MHz signal at 0 dBm to A3A4J1.	Full-scale trace deflection.	Disconnect W25; connect a 2.7 MHz signal at -30 dBm to A3J1 (rear housing), and troubleshoot the mixer, the two transistor amplifiers A3A1, and the diode switches in A3A2 and A3A3.	Troubleshoot LOG/LIN amplifier A3A4.
6. Disconnect W25. Connect a 60 MHz signal at -30 dBm to A3J1.	Full-scale pip deflection.	Troubleshoot W25 and the 60 MHz MHz IF Amplifier A2A4.	Troubleshoot 3rd LO A3A1, and associated circuits.
7. Set IF GAIN/VAR fully CW to CAL. Turn the AMPLITUDE SCALE CAL screwdriver adjust fully counter clockwise and back.	Noise level should vary about 1/2 div with full rotation.	Go to Step 8.	Troubleshoot the 60 MHz preamplifier A2A1A1, cables W19 and W22 and narrowband filter A2A3.
8. Disconnect W5 from A1FL2 and connect an input signal at 1.5 GHz at -30 dBm.	Full-scale deflection on CRT.	Troubleshoot the 1.44 GHz 2nd LO and mixer A2A1A2.	Troubleshoot the 1st LO A1A1 and 1st Mixer A1A2.

PART 2. PHASE LOCK TROUBLESHOOTING

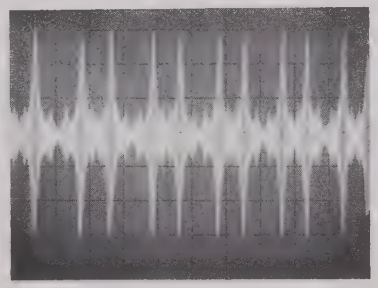
Procedure	Normal Indication	If Indication Is Normal	If Indication Is Abnormal
1. Check ± 12 VDC power supply connections to phaselock circuits when phaselock pushbutton is depressed. Be sure 0 or kHz MULTIPLIER pushbutton is also depressed.	± 12 VDC	Go to step 2.	Check S6, S7, S9, and the associated wiring.
2. Set the CA-6A controls as follows: PHASELOCK Pushbutton.... Depress MHz MULTIPLIER ..... Depress CENTER FREQUENCY.....650 MHz SCAN WIDTH/DIV.....130 Check to ensure -12 VDC is supplied to the power amplifier/comb generator assembly A2A5. Similarly, check for the + 12 VDC supply to the Limiter assembly A2A6, and the reference oscillator assembly A2A7.	-12 VDC +12 VDC		
3. With an oscilloscope, monitor the phase detector output at P2-F or J1-8. Use the main frame sweep output for the oscilloscope horizontal deflection. Use DC coupling.		Check for trouble in shaping amplifier circuit A5.	1) If amplitude is ≤200 mV P-P, check reference oscillator A2A7; its power output should be about 500 mV P-P. 2) If the waveform is offset above or below the zero horizontal axis, check the phase detector and 11.35 MHz filter in A2A7. 3) If the waveform rolls off to the right (e.g., P-P amplitude is about 1/3 of amplitude at left), check the 11.85 MHz amplifier/limiter A2A6. 4) If there is no signal, go to Step 4.
4. Check the output of the 17 MHz oscillator.	Oscillator output should be 6 V p-p , open circuit.	Check for trouble in the 17 MHz comb (harmonic) generator A2A5. If the comb generator operates properly, check the 11.85 reference oscillator A2A7.	Check for trouble in the phase lock mixer A1A4, the hi-pass filter A1FL1, and the phase lock output from the 1st local oscillator A1A1.

TABLE 4-3 VOLTAGE MEASUREMENTS, 100 MHz CALIBRATOR/MARKER GENERATOR A1A3*

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3563			
	Markers	.6	1.3	12.0
	Cal	.8	1.5	12.0

*NOTE: -40 dBm or marker pushbutton depressed.

TABLE 4-4 VOLTAGE MEASUREMENTS, MIXER AND 60 MHz PREAMPLIFIER A2A1

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3134	-10.9	-10.2	0.0

TABLE 4-5 VOLTAGE MEASUREMENTS, 1.44 GHz (SECOND) LO A2A2

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3563	3.0V	2.7V	10.1V
Q2	2N3642	0	-1.1	-5.7
Q3	2N3299	0	-1.2	7.2
Q4	2N3866	0	-.7	-1.4

TABLE 4-6 VOLTAGE MEASUREMENTS, 60 MHz IF AMPLIFIER A2A4*

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3563	5.2	6.0	12
Q2	SE5020	-1.0	-.2	4.1
Q3	2N3563	5.2	6.0	12

*NOTE: IF GAIN set to fully ccw.

TABLE 4-7 VOLTAGE MEASUREMENTS, 17.0 MHz POWER AMPLIFIER AND HARMONIC GENERATOR A2A5*

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N4427	.44	.1	0

TABLE 4-8 VOLTAGE MEASUREMENTS, 11.85 MHz AMPLIFIER AND LIMITER A2A6*

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	A467	2.15	2.88	8.64

		PIN									
		1	2	3	4	5	6	7	8	9	10
A1	CA3012	2.4	2.4	2.4	2.4	10.3	0	0	0	0	11.8

TABLE 4-9 VOLTAGE MEASUREMENTS, PHASE LOCK DETECTOR AND 11.85 MHz REFERENCE OSCILLATOR A2A7*

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3646	5.41	6.21	7.33

TABLE 4-10 VOLTAGE MEASUREMENTS, NARROW BAND SWEPT LOCAL OSCILLATOR A3A1

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3638	.61	0.0	-5.7
Q2	MM4002	-5.06	-5.7	-45.5
Q3	2N3563	3.4	3.8	12
Q4	2N3563	4.9	5.6	12
Q5	2N3563	3.7	4.5	12

		PIN							
		1	2	3	4	5	6	7	8
A1		9.4	0	0	-12	-11.3	0	12	+8.7

*NOTE: Lock pushbutton depressed.

TABLE 4-11 VOLTAGE MEASUREMENTS, 2.7 MHz NARROW BAND FILTER A3A2

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3563	-6.8	-6.1	0.6
Q2	2N3563	- .7	0	12

TABLE 4-12 VOLTAGE MEASUREMENTS, VARIABLE BANDWIDTH AMPLIFIER A3A3*

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3015	-2.6	-2.6	3.94
Q2	2N3015	-7.6	-7.0	5.5
Q3	2N3641	1.51	10.7	11.3
Q4	2N3640	-1.1	-11.7	0
Q5	2N3694	-6.2	-5.6	0
Q6	2N3694	.6	0	3.8
Q7	2N3640	-3.0	-11.9	0
Q8	2N3694	-3.56	-2.93	11.7
Q9	2N3641	1.65	11.0	11.7

	PIN							
	1	2	3	4	5	6	7	8
A1	7.9	6.5	6.5	-11.8	-11.2	1.7	11.7	8.5
A2	7.8	6.5	6.5	0	-10.8	1.5	11.5	8.4

* NOTE: kHz Pushbutton depressed; bandwidth switch at .5 kHz.

TABLE 4-13 VOLTAGE MEASUREMENTS, LOG/LIN AMPLIFIER A3A4

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3563	-7.56	-6.83	0
Q2	2N3563	-7.66	-6.91	0
Q3	2N3563	-7.58	-6.85	0
Q4	2N3563	-7.7	-6.96	0
Q5	2N3563	-7.69	-6.96	0
Q6	2N3563	-7.81	-7.07	0
Q7	2N3563	-7.86	-7.15	0
Q8	2N3641	-7.98	-7.39	12.0

	PIN													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A1	.6	0	0	0	0	-12	0	-12	.6	5.9	.8	.1	12	2.5

TABLE 4-14 VOLTAGE MEASUREMENTS, 17.0 MHz PULLED OSCILLATOR A4

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N4917	-1.1	-1.68	-11.0

TABLE 4-15 VOLTAGE MEASUREMENTS, SHAPING ASSEMBLY/SWEEP GENERATOR A5

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N5133	10.4	11	12
Q2	2N5139	11	10.4	-4.5
Q3	2N5306	-5.6	11.9	12
Q4	2N5139	- 5.0	- 5.6	-12
Q5	2N3904	- 5	- 4.5	- 5
Q6	2N5139	- 0.65	- 1.4	- 0.72
Q7	2N5306	- 1.0	0	12
Q8	2N5133	- 6.1	- 5.5	0
Q9	2N5139	- 5.3	- 6.1	- 7.6
Q10	2N4889	620 mV	-400 mV	580 mV
Q11	2N4889	620 mV	175 mV	- 1.0
Q12	MM4002	-10 mV	-630 mV	-92

		PIN													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
A1	MC1007	-1.3	-1.3	-1.3	- .7	- 1.7	-1.6	-5.4	-1.9	- .9	-1.7	- .6	-1.6	-.4	
A2	MC1014	- .8	-1.5	0	0	- .8	-1.7	-5.4	-1.7	-1.6	0	0	-1.6	-.8	
A3	MC1035	- .7	-1.7	-1.3	- .9	- .6	- .6	-5.4	-1.3	-1.1	-3.4	-1.1	-1.7	-.7	
A4	MA709C	8.1	0	0	-12.0	-11.4	.5	+12	8.8						

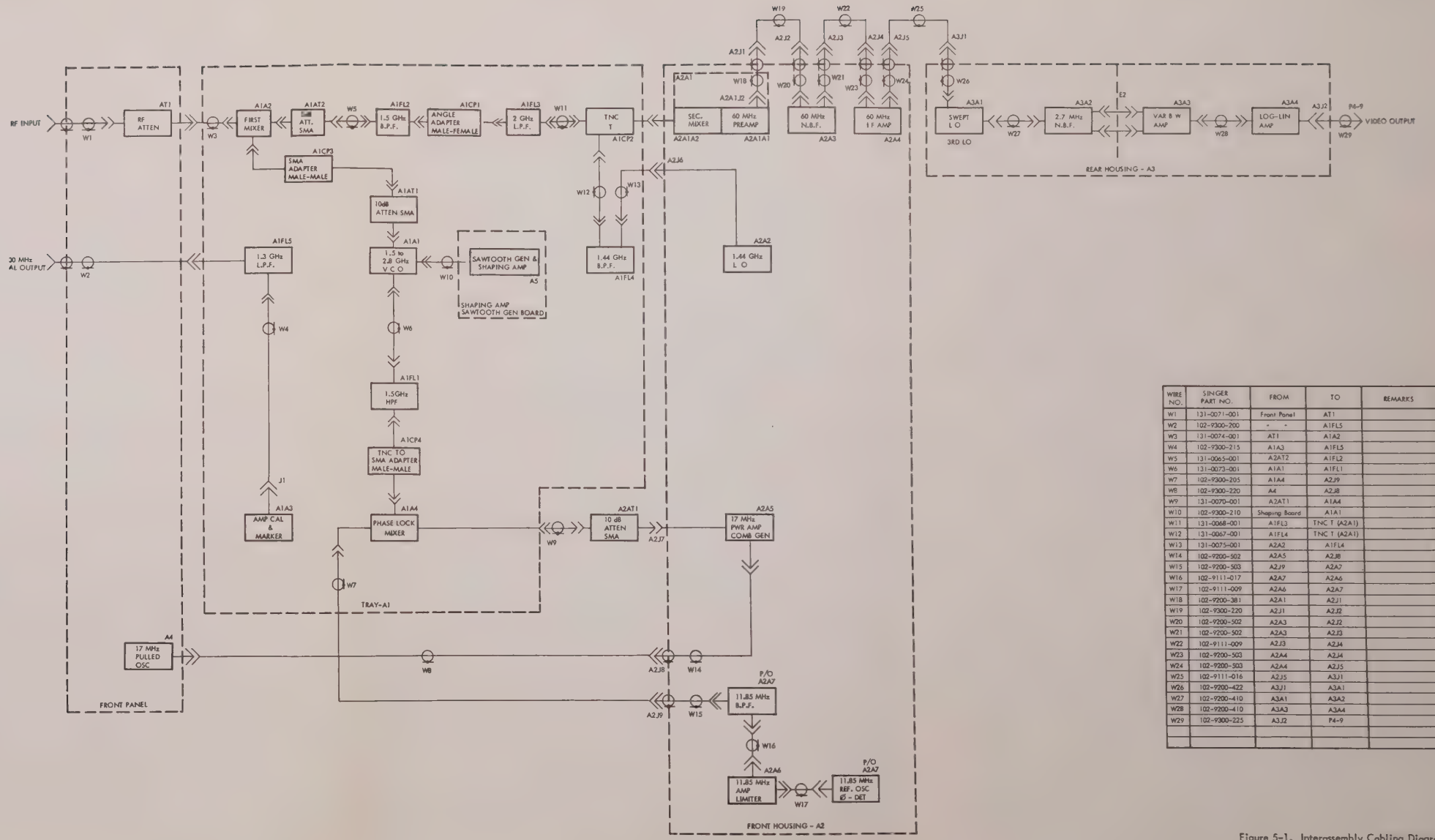
NOTE: No sweep selected.

SECTION V

SCHEMATICS

Schematics are included in the following order:

Figure 5-1.	Interassembly Cabling Diagram
Figure 5-2.	Tray Assembly, A1, Interconnect Diagram
Figure 5-3.	Front Housing Assembly, A2, Interconnect Diagram
Figure 5-4.	1.44 GHz Local Oscillator, A2A2, Schematic Diagram
Figure 5-5.	Second Mixer and 60 MHz Preamplifier, A2A1, Schematic Diagram
Figure 5-6.	60 MHz Narrow Band Filter, A2A3, Schematic Diagram
Figure 5-7.	60 MHz IF Amplifier, A2A4, Schematic Diagram
Figure 5-8.	Rear Housing Assembly, A3, Schematic Diagram
Figure 5-9.	Third Local Oscillator and Connector, A3A1, Schematic Diagram
Figure 5-10.	2.7 MHz Narrow Band Filter, A3A2, Schematic Diagram
Figure 5-11.	Variable Bandwidth Amplifier, A3A3, Schematic Diagram
Figure 5-12.	LOG/LIN Amplifier, A3A4, Schematic Diagram
Figure 5-13.	Sawtooth Generator and Inverter, P/O A5, Schematic Diagram
Figure 5-14.	Shaping Amplifier, P/O A5, Schematic Diagram
Figure 5-15.	17.0 MHz Pulled Oscillator, A4, Schematic Diagram
Figure 5-16.	17.0 MHz Power Amplifier, A2A5, Schematic Diagram
Figure 5-17.	11.85 MHz Amplifier/Limiter, A2A6, Schematic Diagram
Figure 5-18.	Phase Lock and 11.85 Reference Oscillator, A2A7, Schematic Diagram
Figure 5-19.	100 MHz Calibrator/Marker Generator, A1A3, Schematic Diagram
Figure 5-20.	CA-6A Wiring/Interconnection Diagram



WIRE NO.	SINGER PART NO.	FROM	TO	REMARKS
W1	131-0071-001	Front Panel	AT1	
W2	102-9300-200	" "	A1FL5	
W3	131-0074-001	AT1	A1A2	
W4	102-9300-215	A1A3	A1FL5	
W5	131-0065-001	A2AT2	A1FL2	
W6	131-0073-001	A1A1	A1FL1	
W7	102-9300-205	A1A4	A2J9	
W8	102-9300-220	A4	A2J8	
W9	131-0070-001	A2AT1	A1A4	
W10	102-9300-210	Shaping Board	A1A1	
W11	131-0068-001	A1FL3	TNC T (A2A1)	
W12	131-0067-001	A1FL4	TNC T (A2A1)	
W13	131-0075-001	A2A2	A1FL4	
W14	102-9200-502	A2A5	A2J8	
W15	102-9200-503	A2J9	A2A7	
W16	102-9111-017	A2A7	A2A6	
W17	102-9111-009	A2A6	A2A7	
W18	102-9200-381	A2A1	A2J1	
W19	102-9300-220	A2J1	A2J2	
W20	102-9200-502	A2A3	A2J2	
W21	102-9200-502	A2A3	A2J3	
W22	102-9111-009	A2J3	A2J4	
W23	102-9200-503	A2A4	A2J4	
W24	102-9200-503	A2A4	A2J5	
W25	102-9111-016	A2J5	A3J1	
W26	102-9200-422	A3J1	A3A1	
W27	102-9200-410	A3A1	A3A2	
W28	102-9200-410	A3A3	A3A4	
W29	102-9300-225	A3J2	P4-9	

Figure 5-1. Interassembly Cabling Diagram

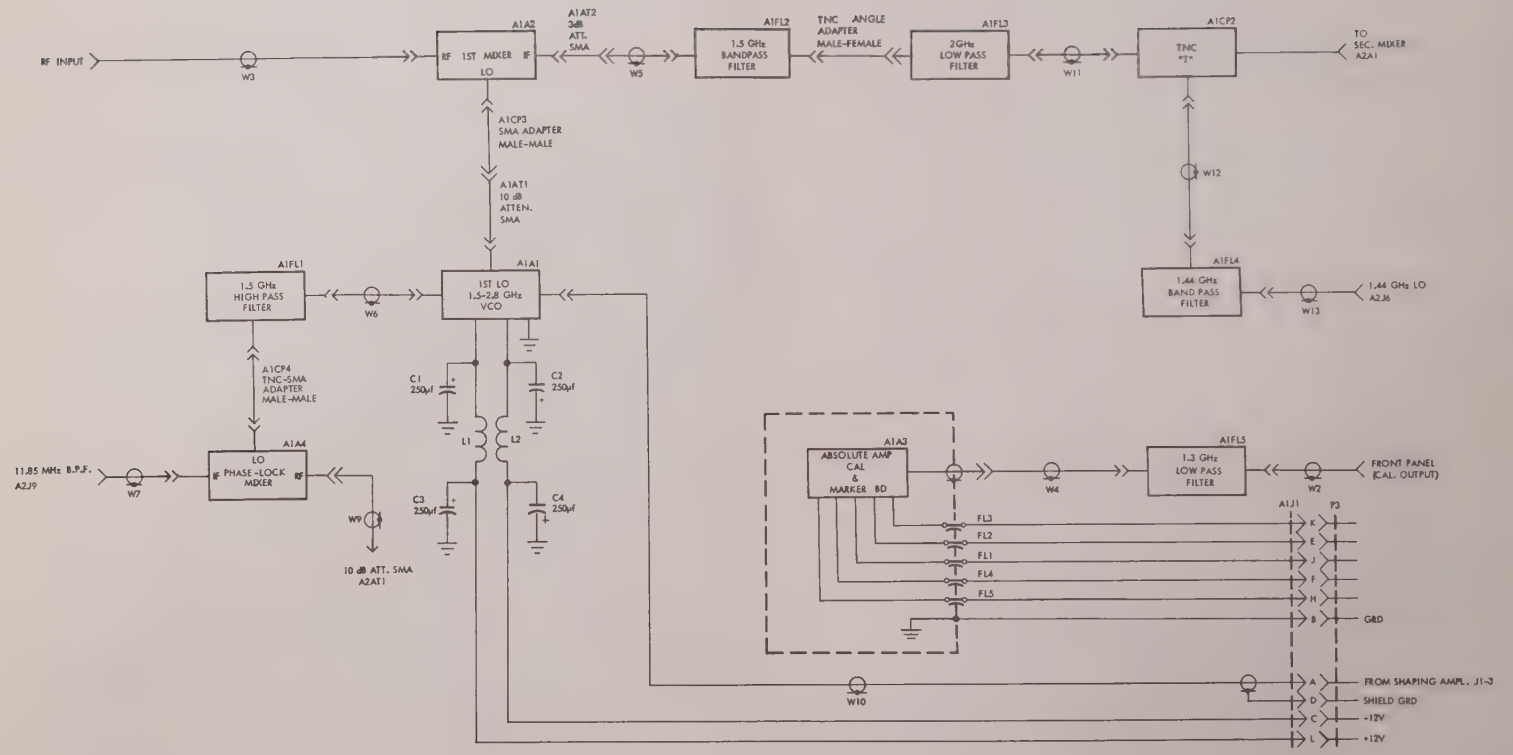


Figure 5-2. Tray Assembly, A1, Interconnect Diagram

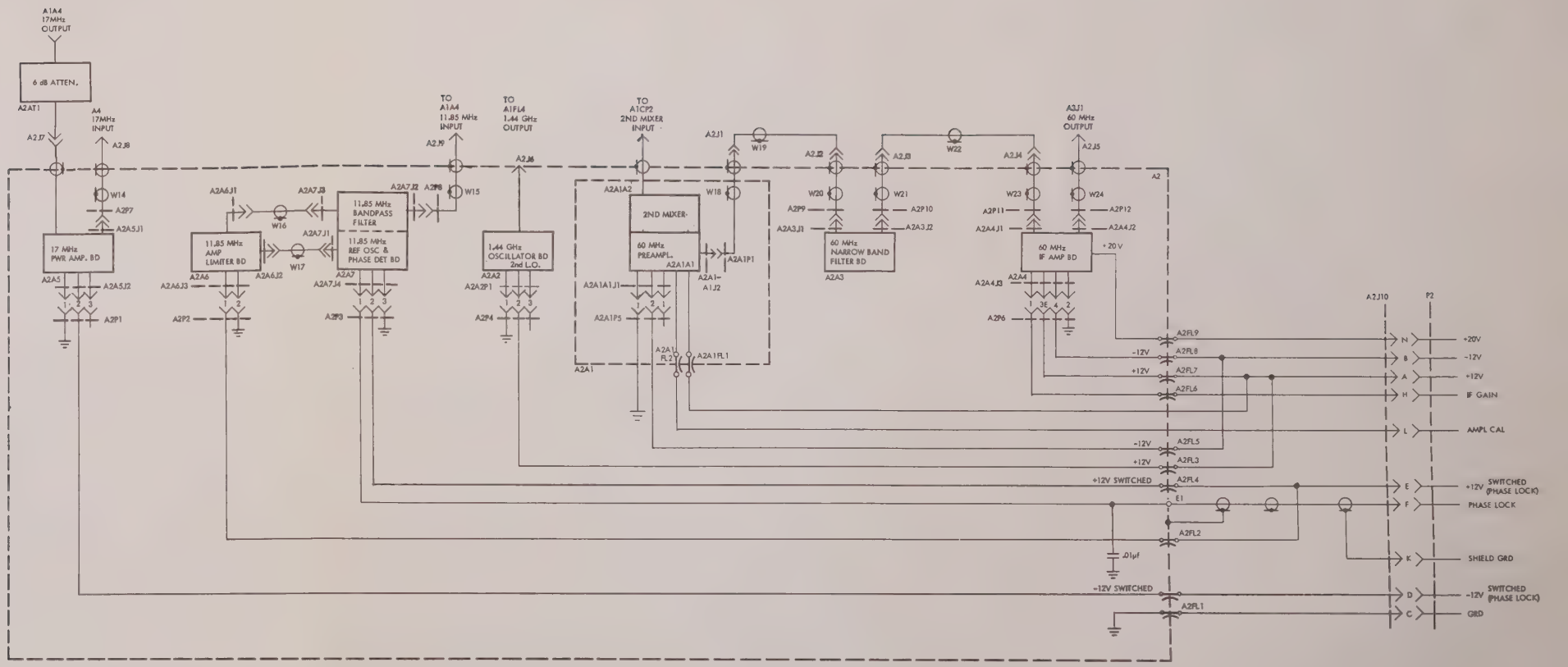


Figure 5-3. Front Housing Assembly, A2, Interconnect Diagram

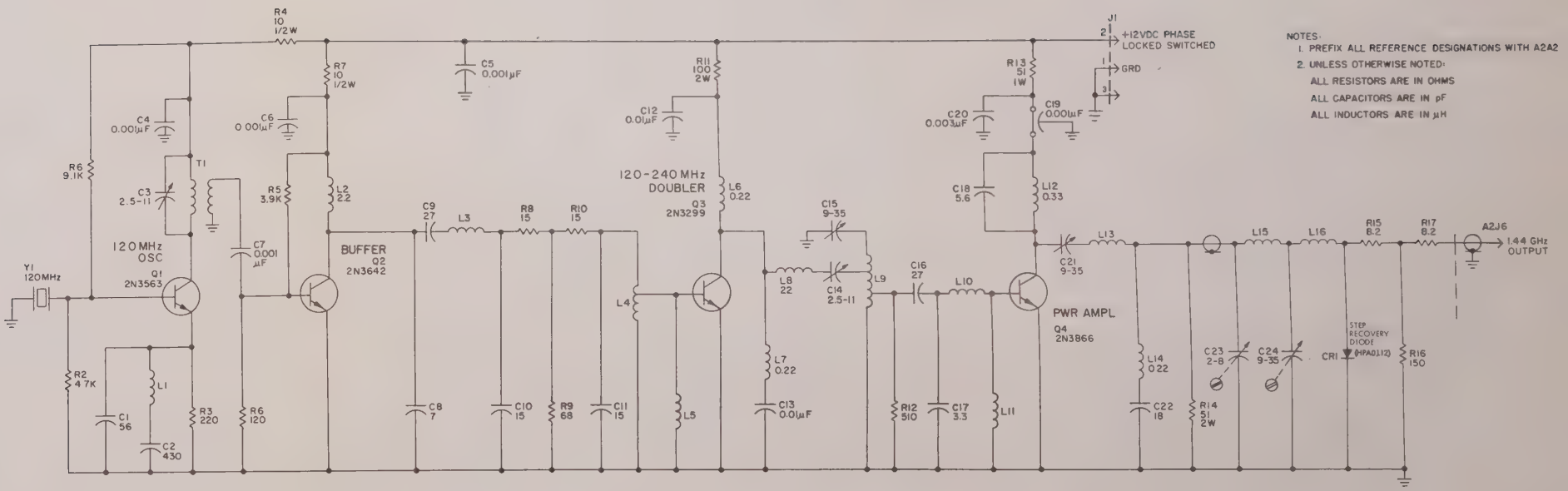


Figure 5-4. 1.44 GHz Second Local Oscillator, A2A2, Schematic Diagram

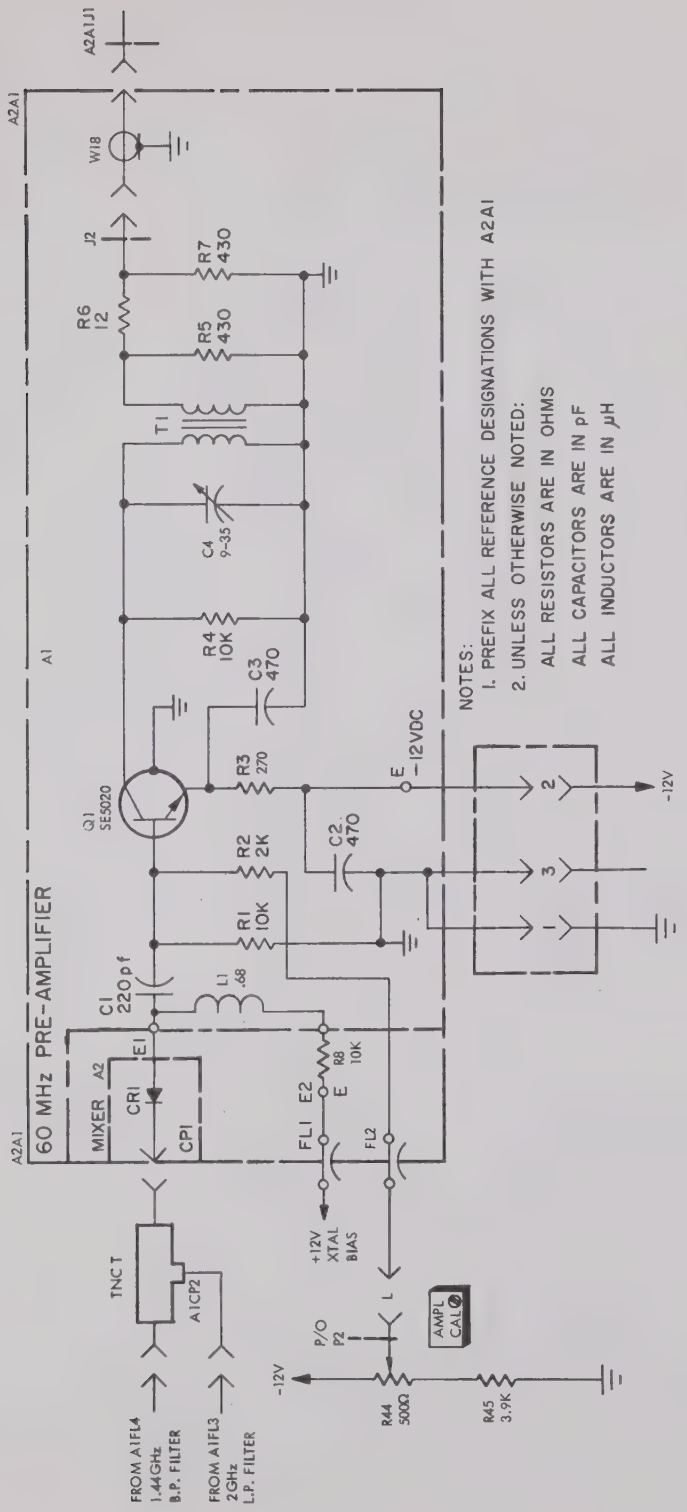


Figure 5-5. Second Mixer and 60 MHz Pre-amplifier, A2A1, Schematic Diagram

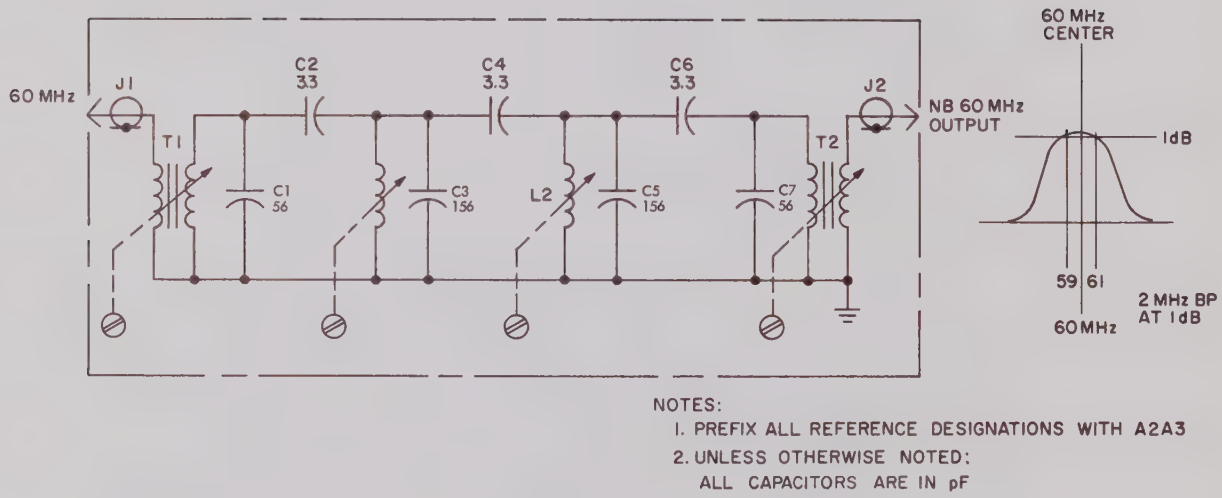


Figure 5-6. 60 MHz Narrow Band Filter, A2A3, Schematic Diagram

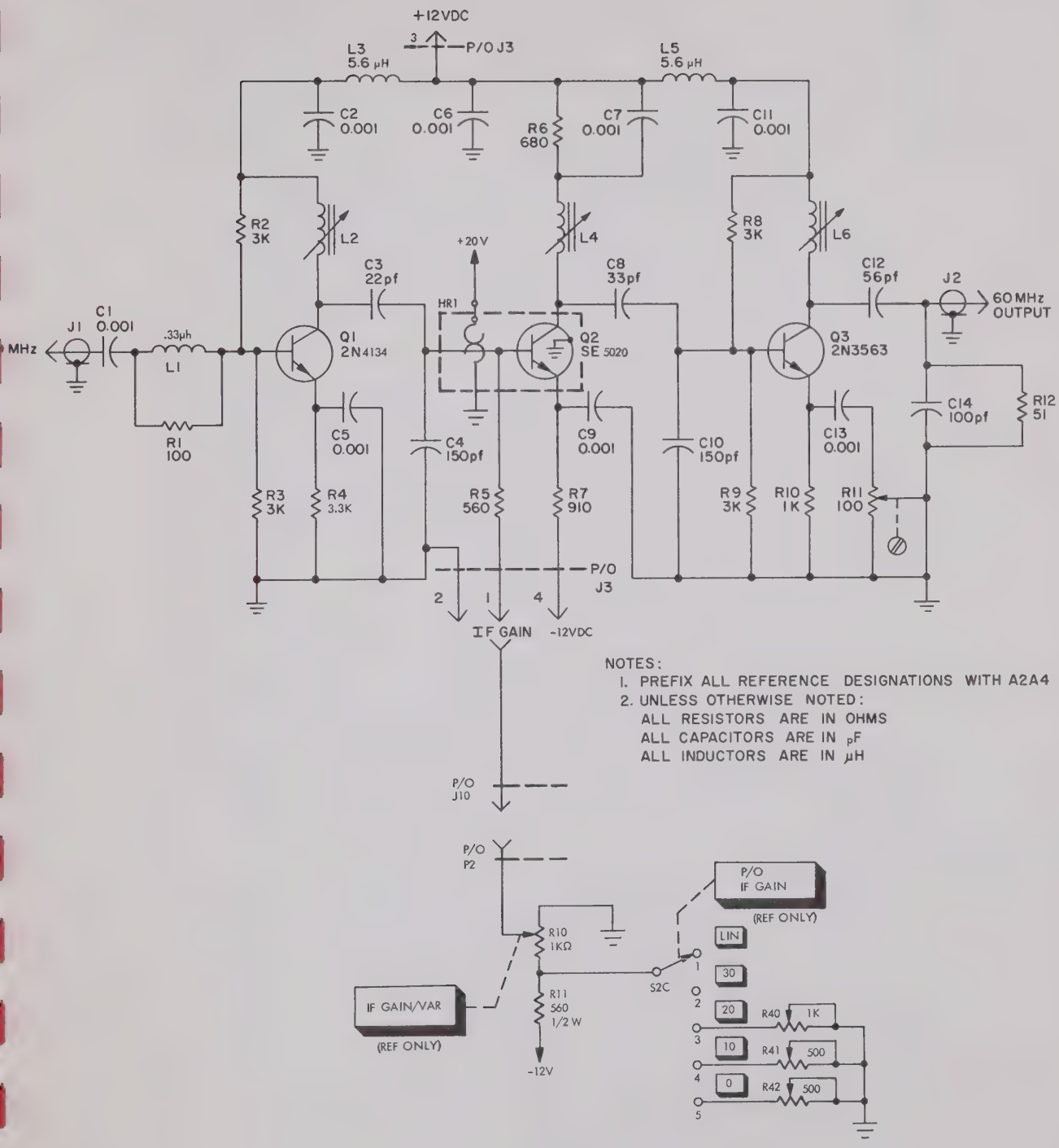
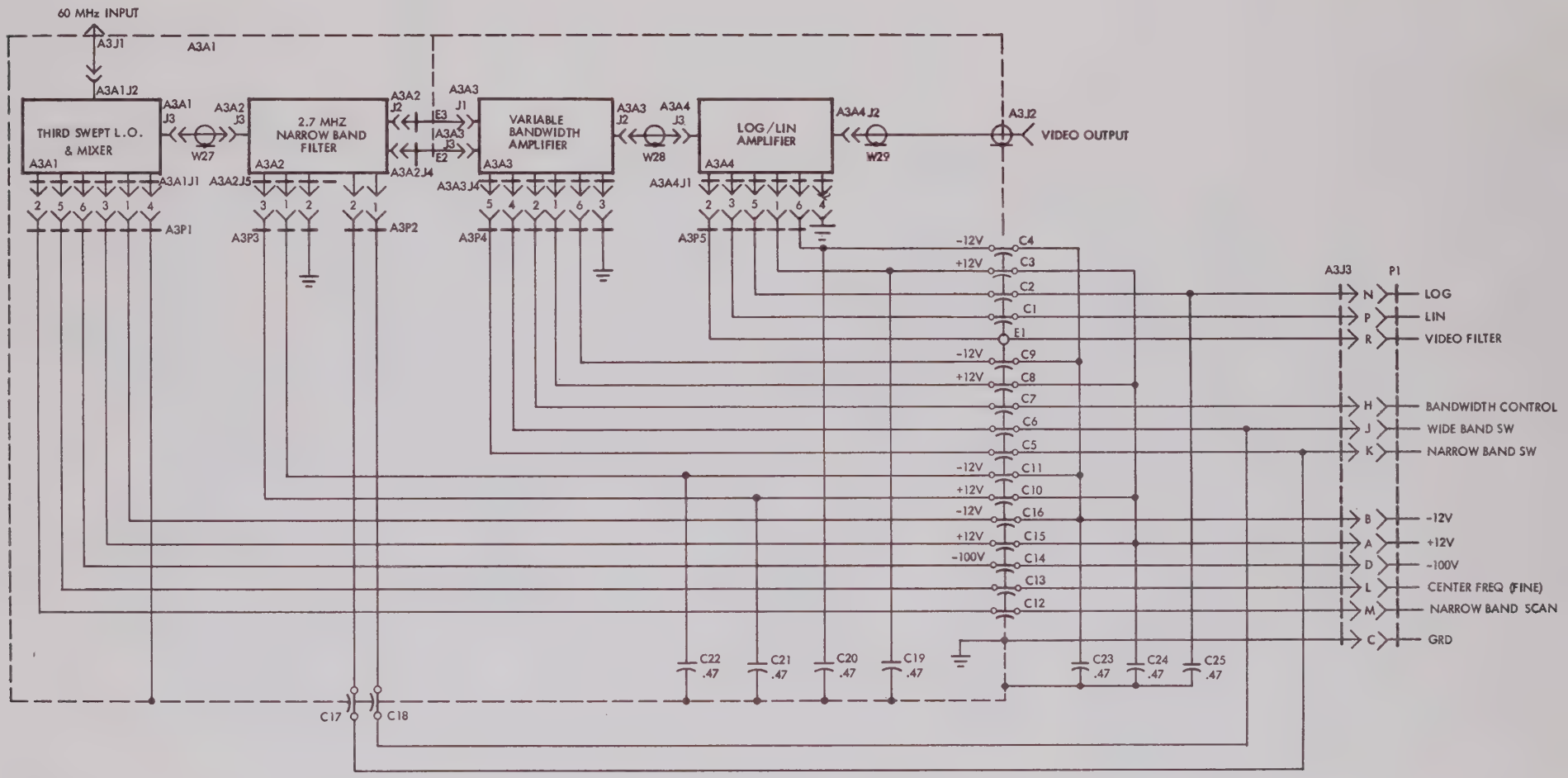


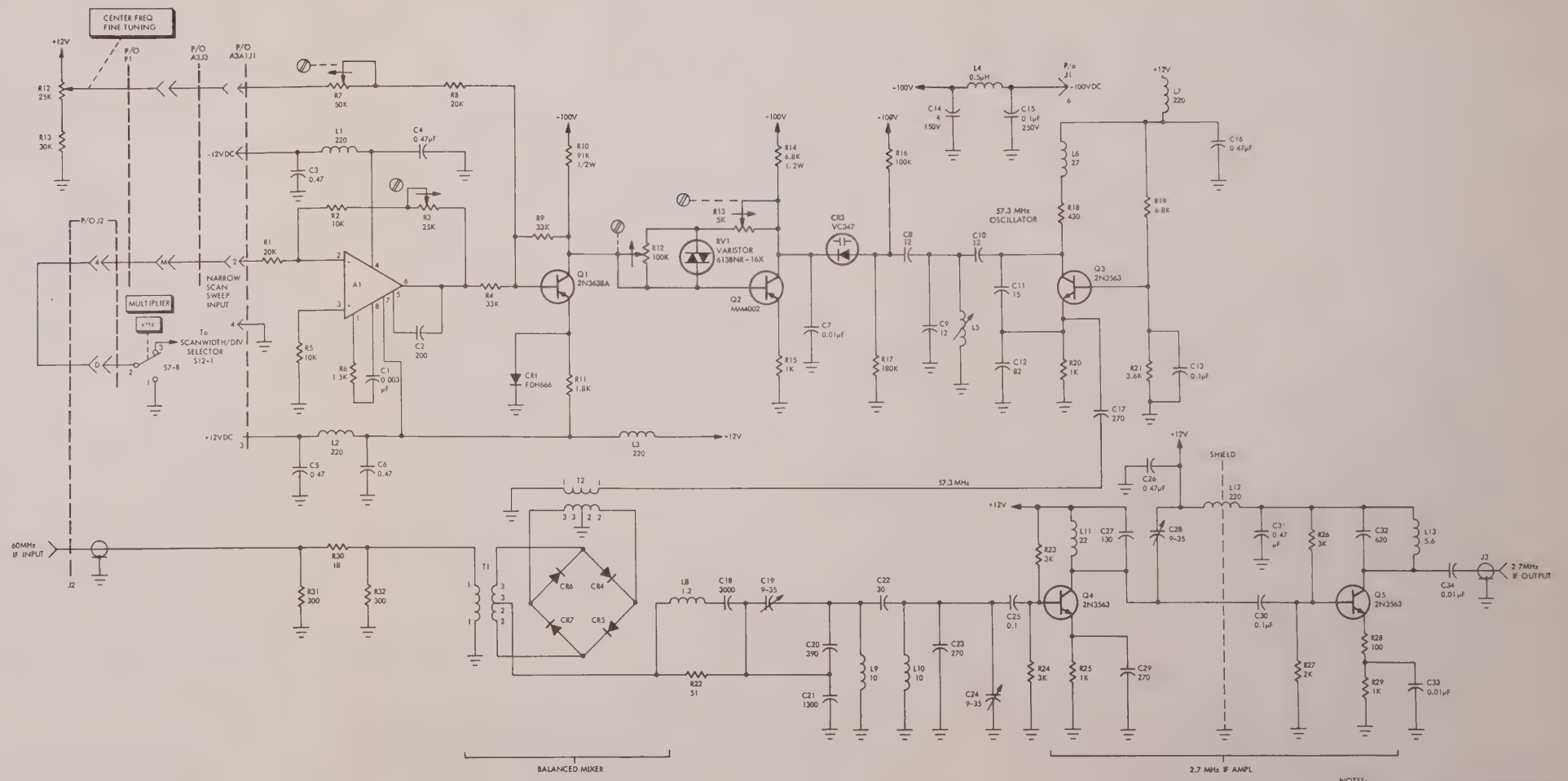
Figure 5-7. 60 MHz IF Amplifier, A2A4, Schematic Diagram



NOTE:

ALL FEED THRU CAPACITORS ARE 1000 PF
EXCEPT C3, C4, C8, C9, C10, C11 & C15
WHICH ARE 0.02 μf

Figure 5-8. Rear Housing Assembly, A3, Schematic Diagram



NOTES:
1. PREFIX ALL REFERENCE DESIGNATIONS WITH A3A1
2. UNLESS OTHERWISE NOTED
   ALL RESISTORS ARE IN OHMS
   ALL CAPACITORS ARE IN pF
   ALL INDUCTORS ARE IN μH

Figure 5-9. Third Local Oscillator and Converter, A3A1, Schematic Diagram

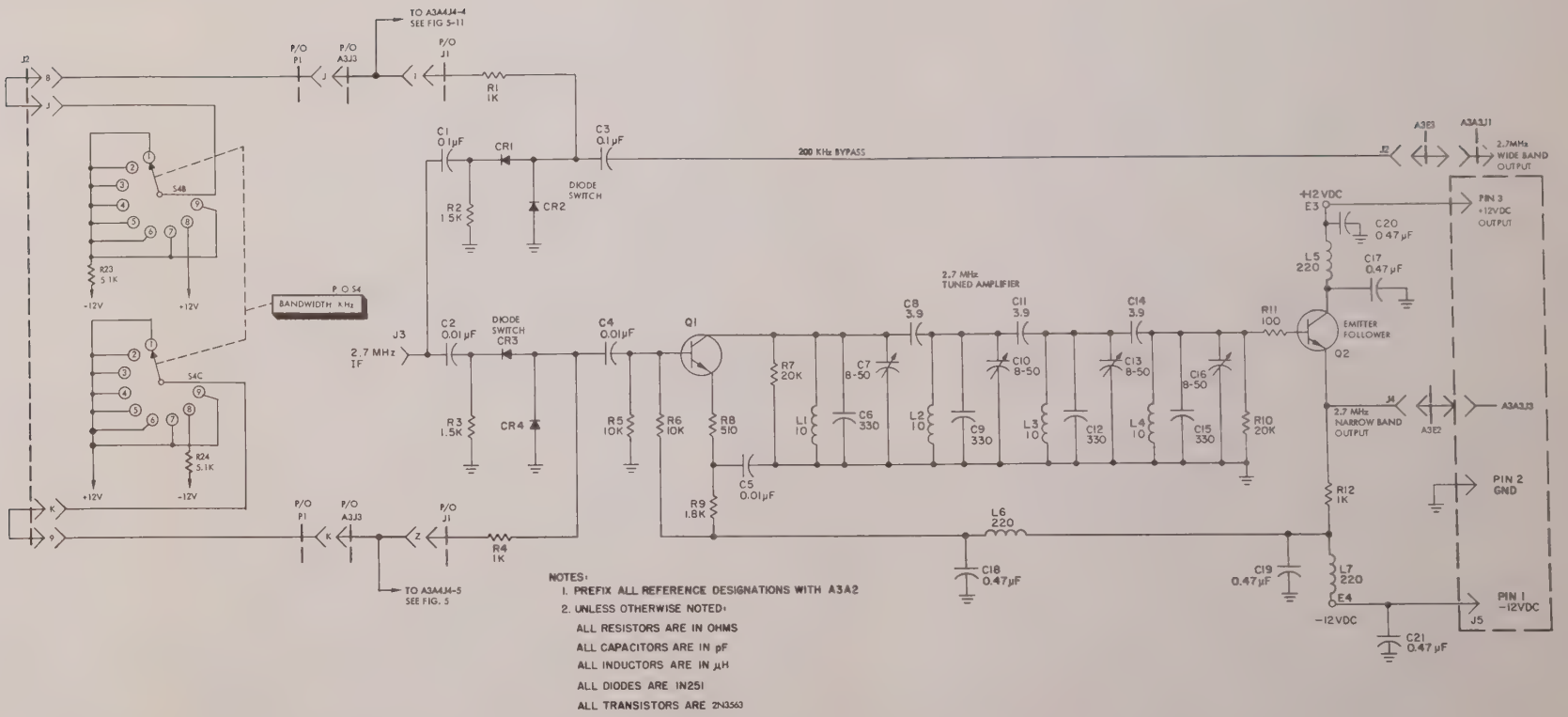


Figure 5-10. 2.7 MHz Narrow Band Filter, A3A2, Schematic Diagram

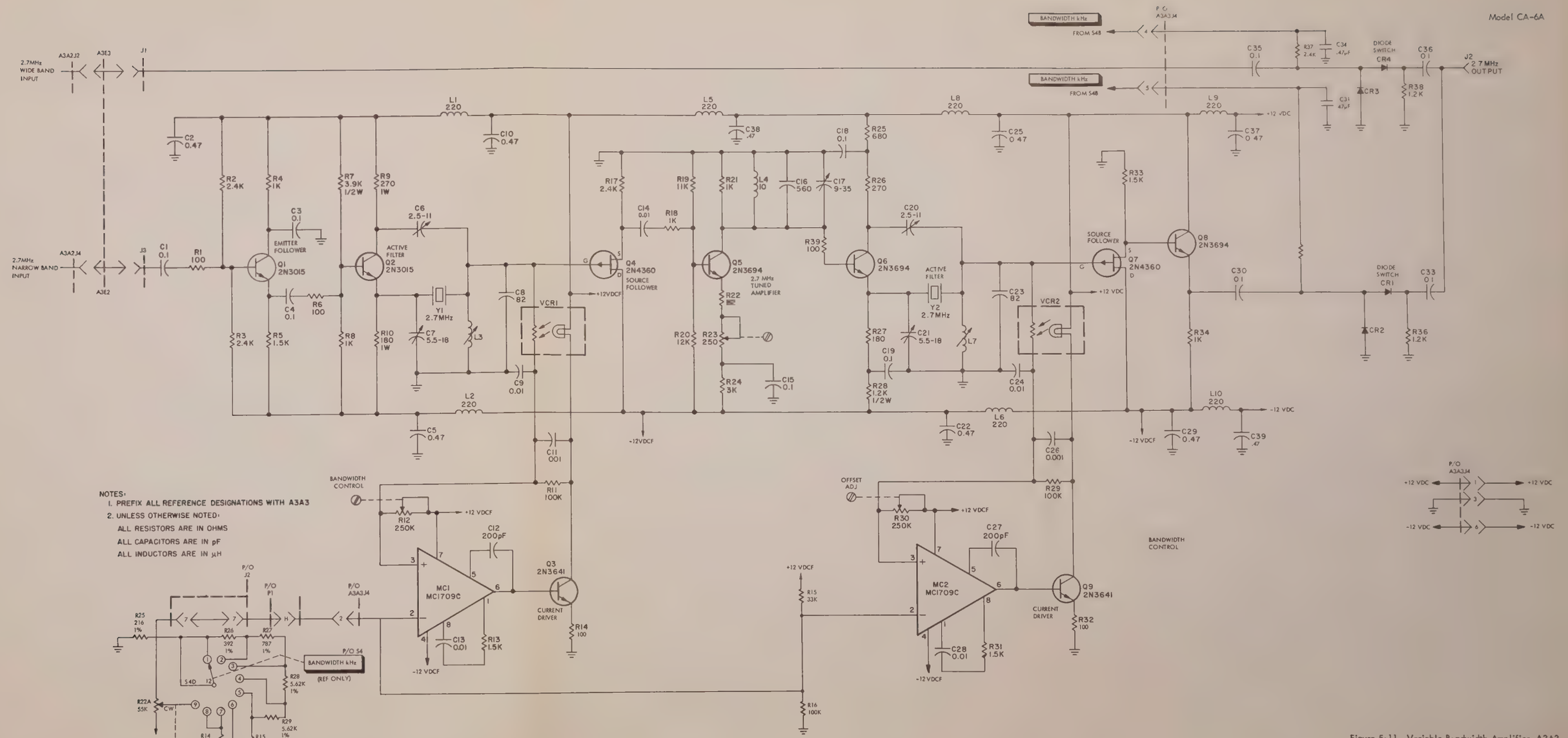
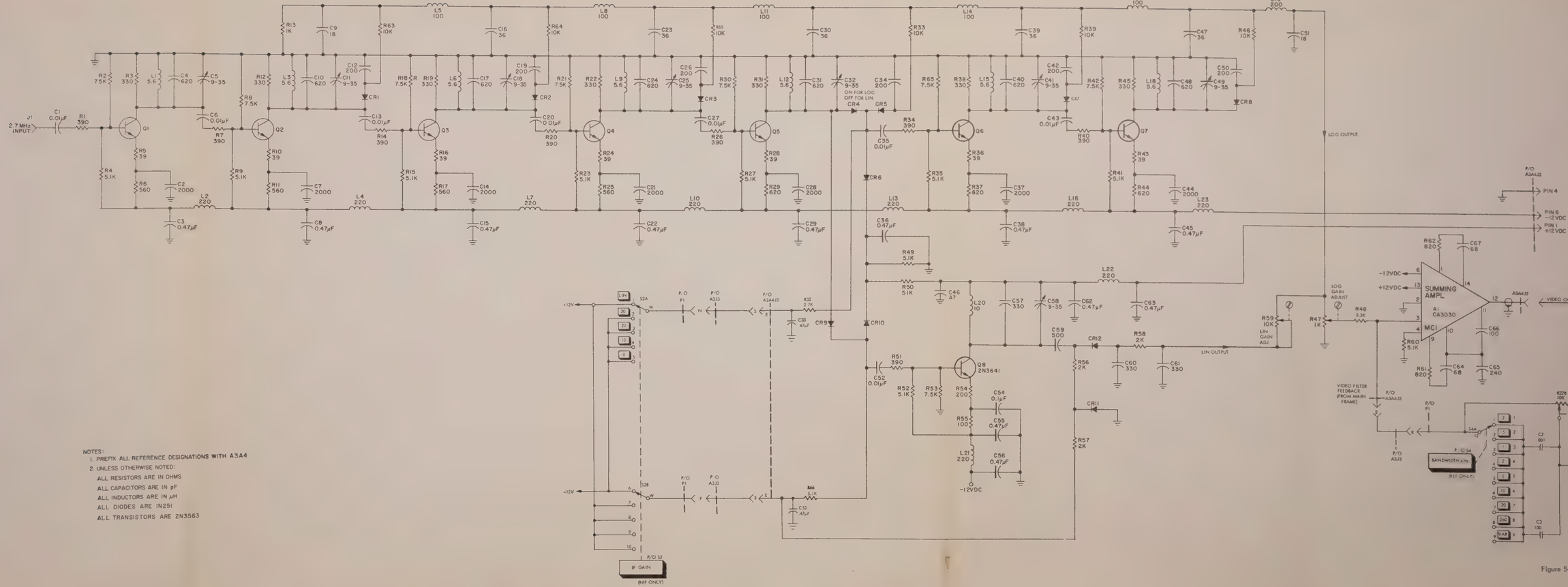


Figure 5-11. Variable Bandwidth Amplifier, A3A3, Schematic Diagram



NOTES:
1. PREFIX ALL REFERENCE DESIGNATIONS WITH A3A4
2. UNLESS OTHERWISE NOTED:
   ALL RESISTORS ARE IN OHMS
   ALL CAPACITORS ARE IN pF
   ALL INDUCTORS ARE IN μH
   ALL DIODES ARE 1N251
   ALL TRANSISTORS ARE 2N3563

Figure 5-12. LOG/LIN Amplifier, A3A4, Schematic Diagram

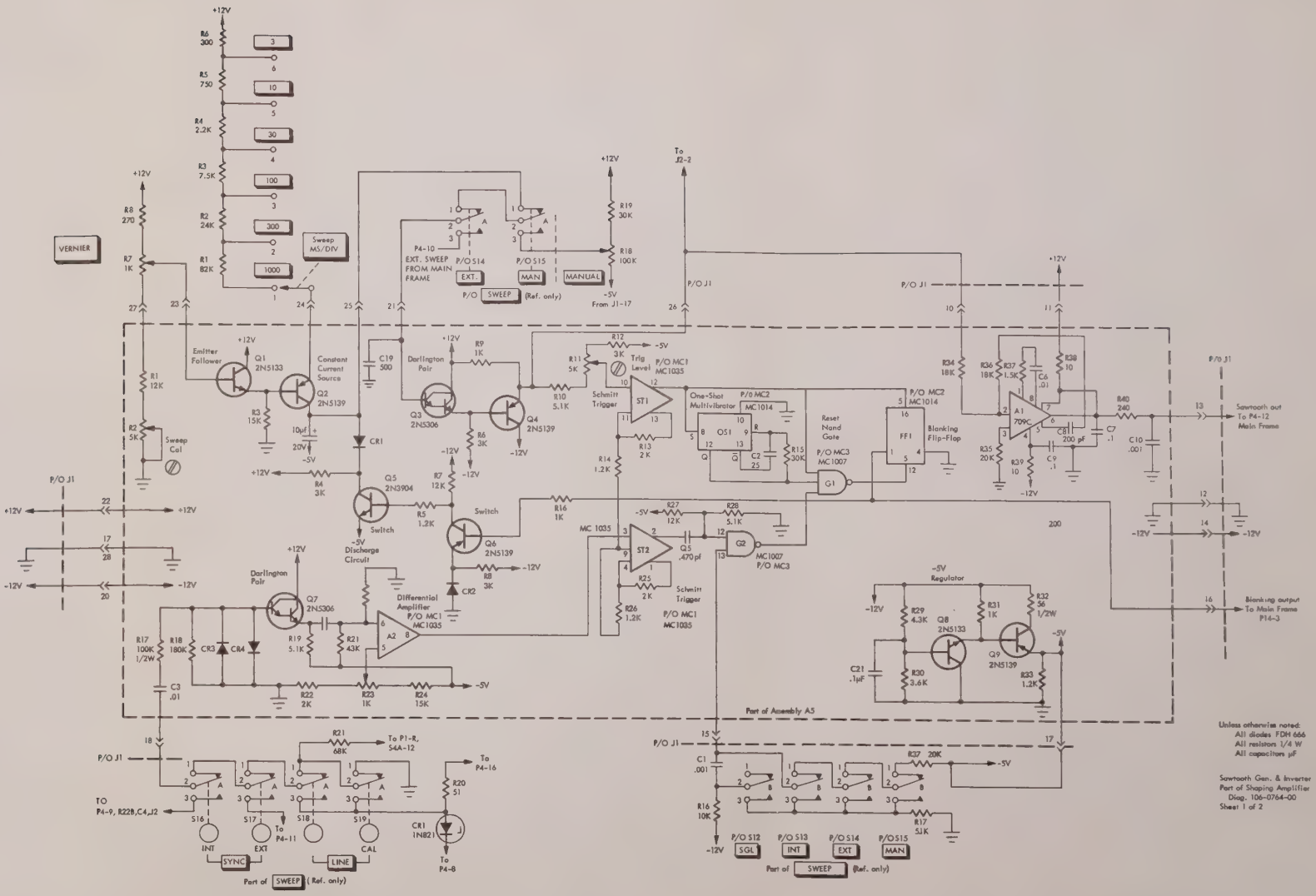
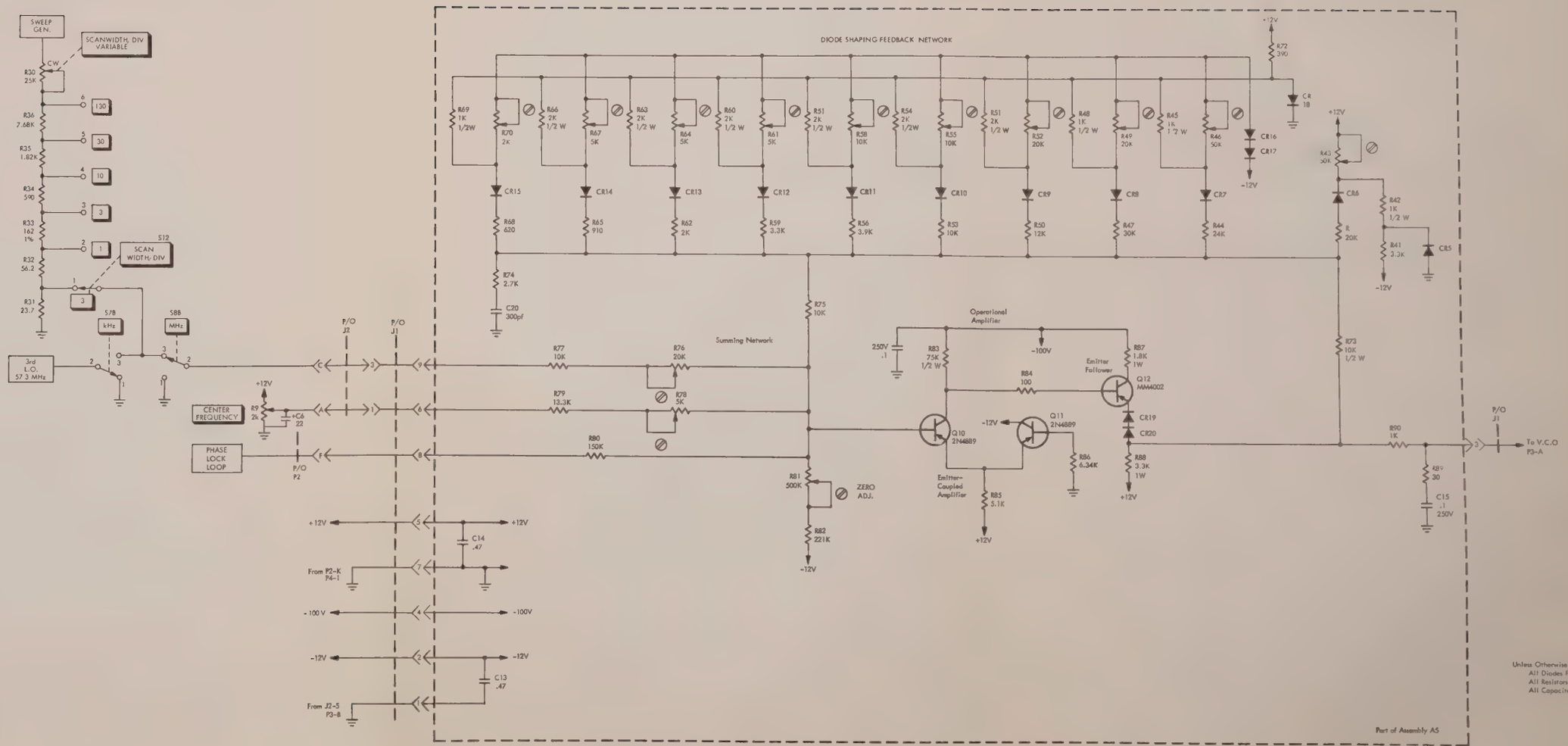
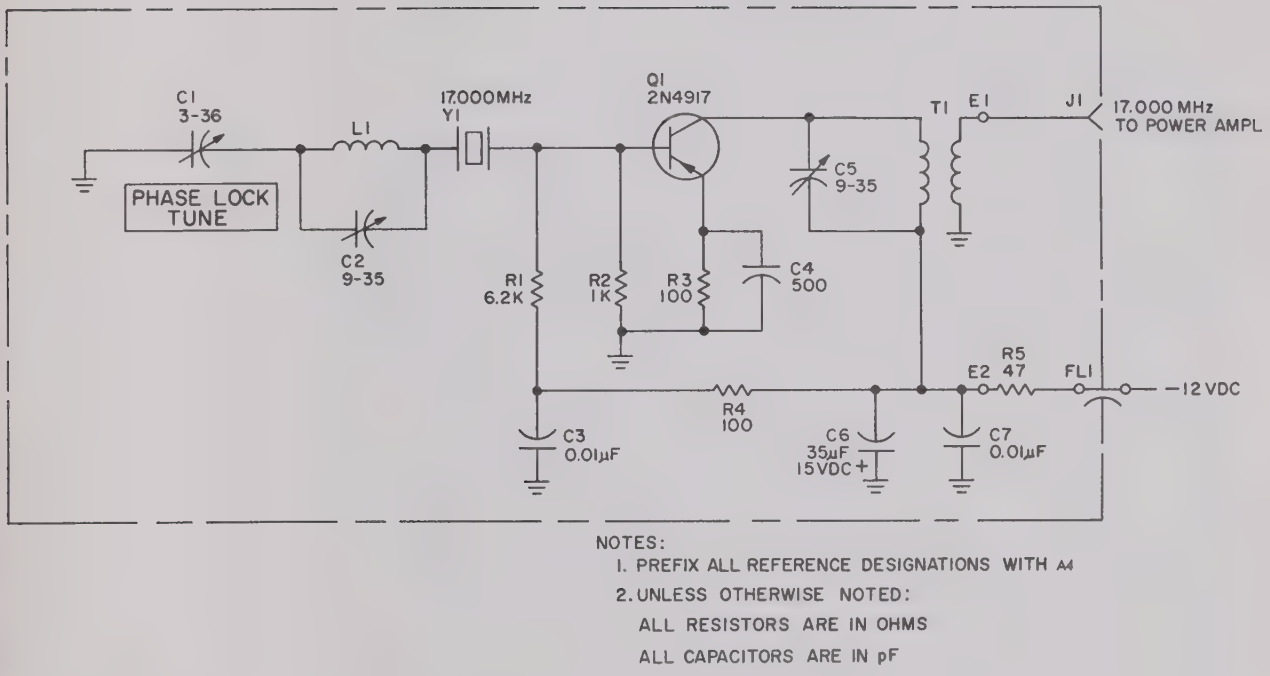


Figure 5-13. Sawtooth Generator and Inverter, P/O A5, Schematic Diagram



Unless Otherwise Noted:
All Diodes FDH 666
All Resistors 1/4 W
All Capacitors μf

Figure 5-14. Shaping Amplifier, P/O A5, Schematic Diagram



NOTES:
1. PREFIX ALL REFERENCE DESIGNATIONS WITH A4
2. UNLESS OTHERWISE NOTED:
   ALL RESISTORS ARE IN OHMS
   ALL CAPACITORS ARE IN pF

Figure 5-15. 17.0 MHz Pulled Oscillator, A4, Schematic Diagram

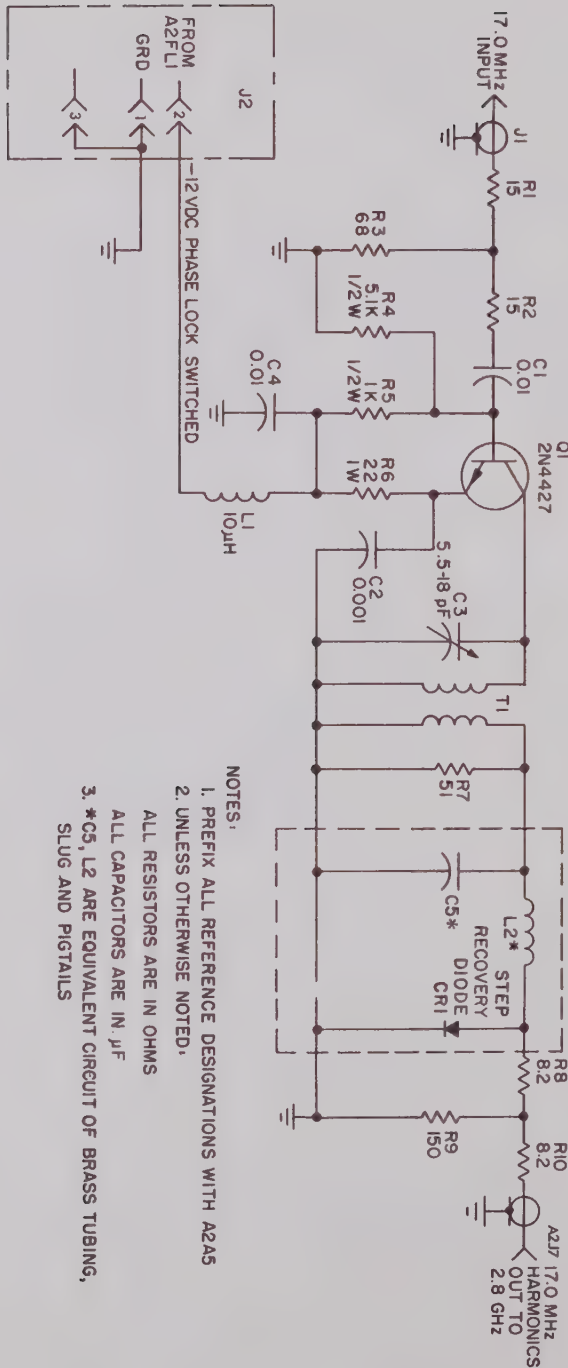


Figure 5-16. 17.0 MHz Power Amplifier, A2A5, Schematic Diagram

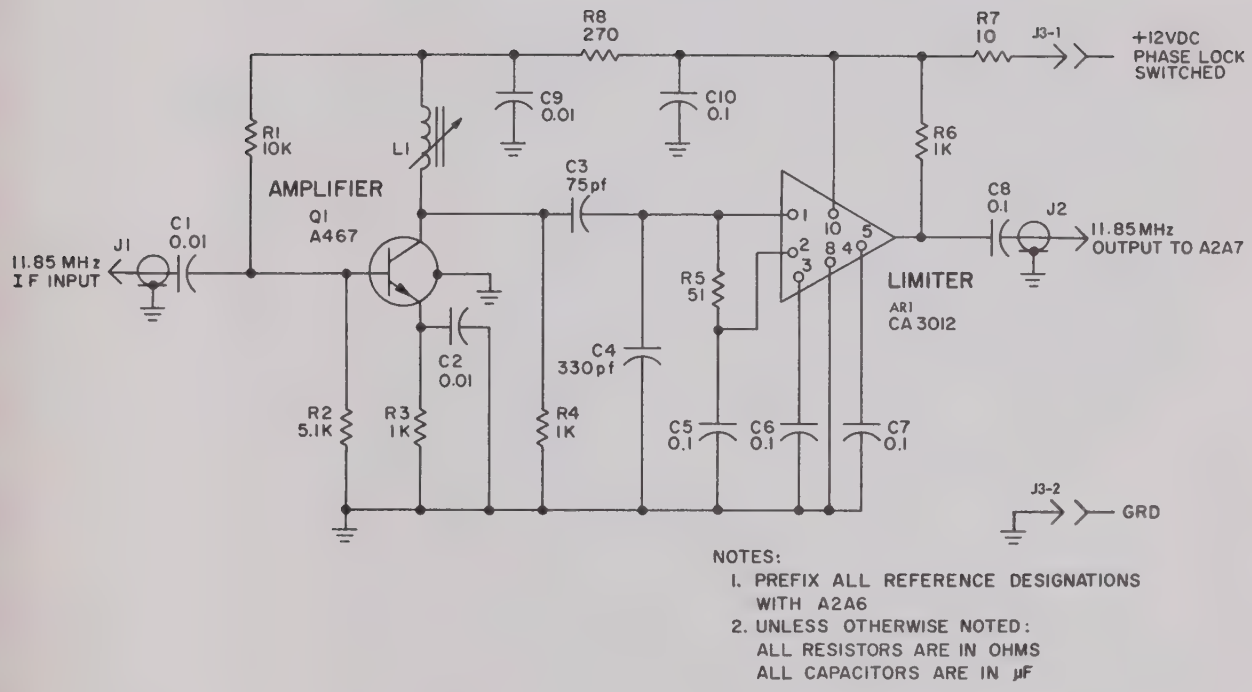
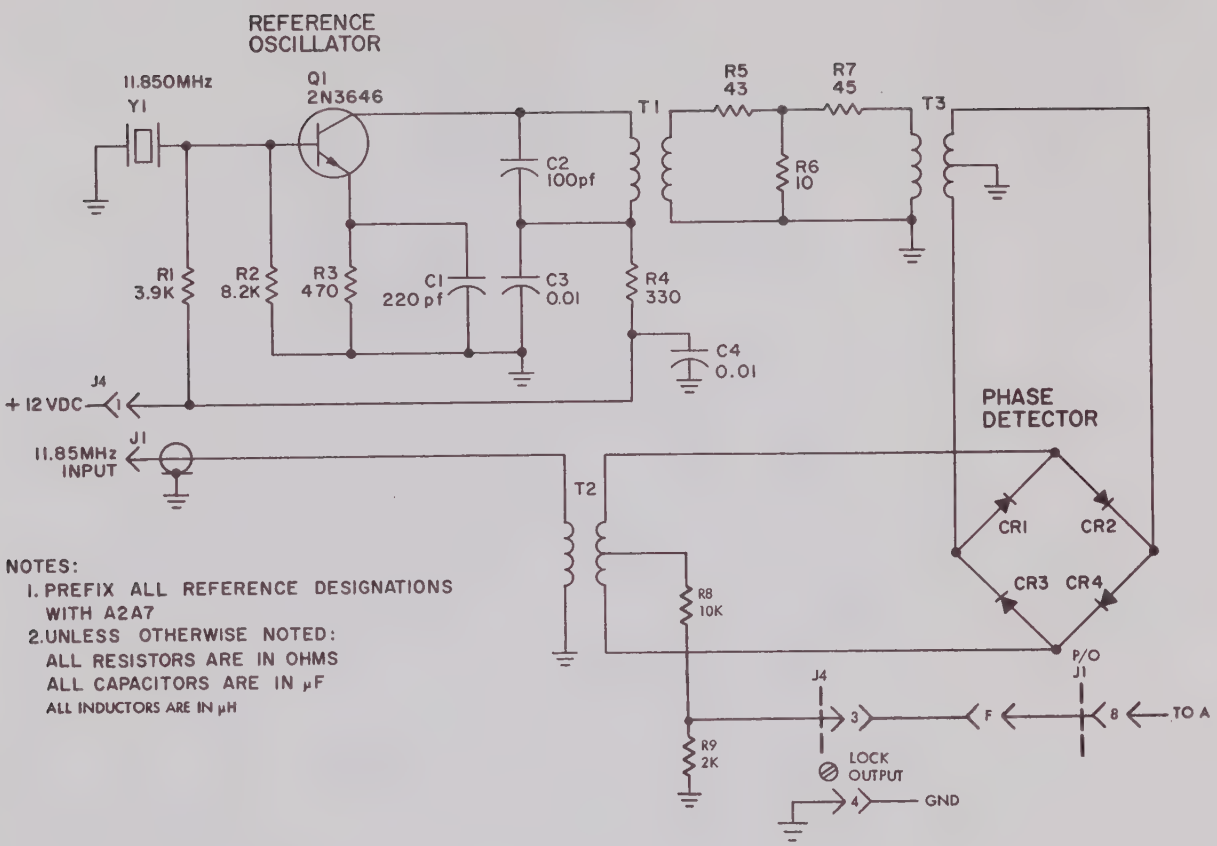


Figure 5-17. 11.85 MHz Amplifier/Limiter, A2A6, Schematic Diagram



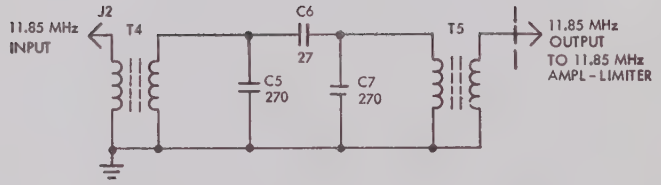
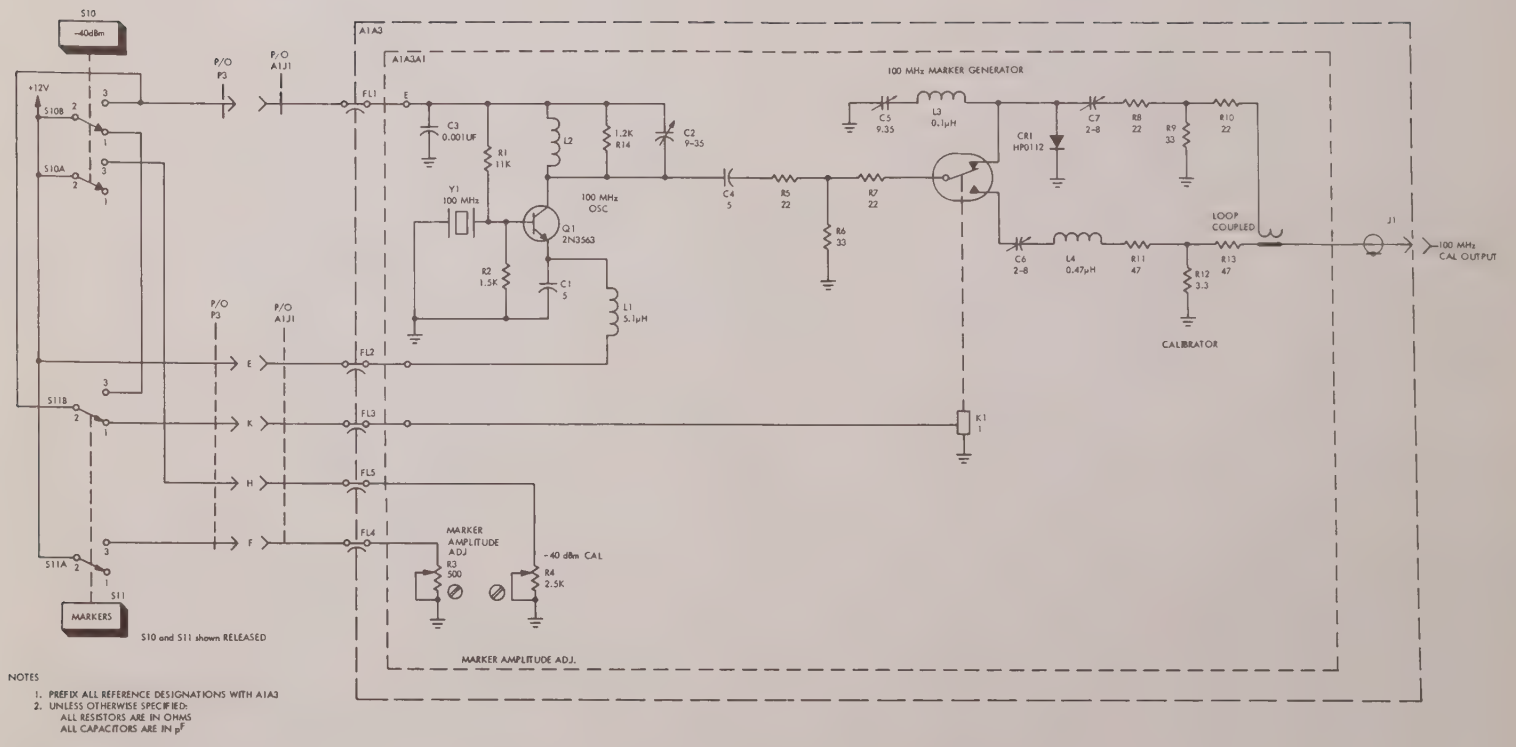


Figure 5-18. Phase Lock Detector and 11.85 Reference Oscillator, A2A7, Schematic Diagram



NOTES

1. PREFIX ALL REFERENCE DESIGNATIONS WITH A1A3
2. UNLESS OTHERWISE SPECIFIED:
   ALL RESISTORS ARE IN OHMS
   ALL CAPACITORS ARE IN pF

Figure 5-19. 100 MHz Calibrator/Marker Generator, A1A3, Schematic Diagram

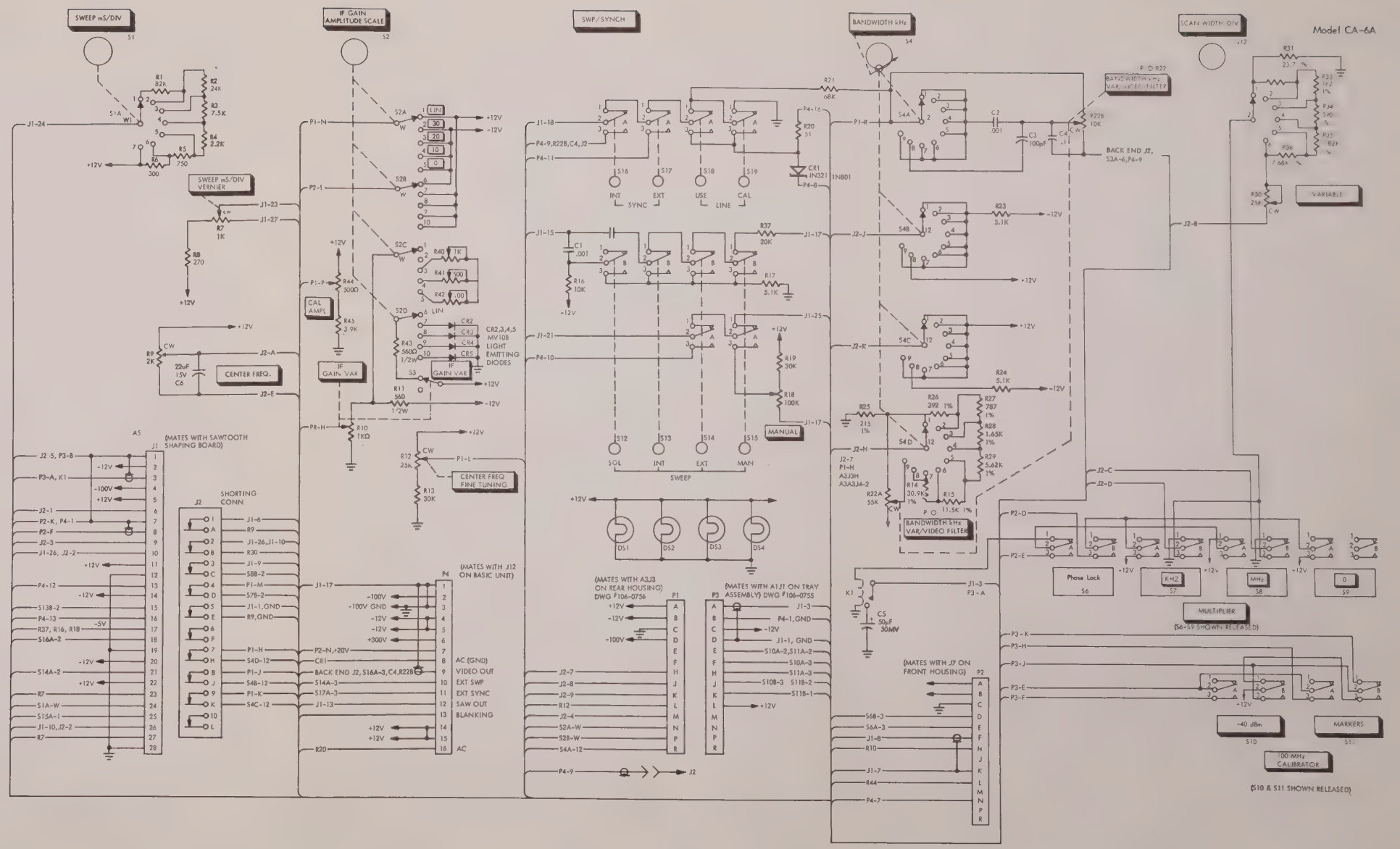


Figure 5-20. CA-6A Wiring/Interconnect Diagram

SECTION VI

PARTS LIST

6-1. GENERAL INFORMATION.

This section contains inf n necessary for ordering replacement parts. Table ists parts in alpha-numerical order of their reference designators, including the Singer part number.

6-2. ORDERING INFORMATION.

To obtain replacement parts, address order for replacement parts to Singer Co., Palo Alto Operation.

To order a part not listed, include the following information:

a. Instrument model number.
b. Instrument serial number.
c. Description of the part.
d. Function and location of the part.

TABLE 6-1 LIST OF ASSEMBLIES

Circuit Reference	Description	Singer Part No.
	Chassis Assembly	
A1	Tray Assembly	103-2085-002
A1A1	Voltage Controlled Oscillator*	132-0421-002
A1A2	Mixer, Option 4*	134-0065-001
A1A3	Absolute Amplifier Calibrator Assembly	103-2051-001
A1A4	Mixer, Option 3*	134-0064-001
A2	Front Housing Assembly	103-2079-001
A2A1	60 MHz Pre-amplifier Assembly	103-2067-001
A2A1A1	60 MHz Pre-amplifier	103-2036-001
A2A1A2	60 MHz Mixer Assembly	103-1761-001
A2A2	1.44 GHz 2nd LO Assembly	103-2037-001
A2A3	60 MHz Narrow Band Filter Assembly	103-2045-001
A2A4	60 MHz Amplifier Assembly	103-2038-001
A2A5	17.0 MHz Power Amplifier Assembly	103-2046-001
A2A6	11.85 MHz Amplifier/Limiter Assembly	103-2040-001
A2A7	11.85 MHz Reference Oscillator Assembly	103-2041-001
A3	Rear Housing Assembly	103-2060-001
A3A1	Third Swept Local Oscillator Assembly	103-2033-001
A3A2	2.7 MHz Narrow Band Filter Assembly	103-2034-001
A3A3	Variable Bandwidth Amplifier Assembly	103-2032-001
A2A4	LOG/LIN Amplifier Assembly	103-2031-001
A4	17.0 MHz Pulled Oscillator Assembly	103-2057-001
A5	Shaping Assembly	103-2035-001

* Non-field-repairable plug-in assemblies.

WIRE LIST

WIRE NO.	SINGER PART NO.	FROM	TO
W1	131-0071-001	Front Panel	AT1
W2	102-9300-200	" "	A1FL5
W3	131-0074-001	AT1	A1A2
W4	102-9300-215	A1A3	A1FL5
W5	131-0065-001	A2AT2	A1FL2
W6	131-0073-001	A1A1	A1FL1
W7	102-9300-205	A1A4	A2J9
W8	102-9300-220	A4	A2J8
W9	131-0070-001	A2AT1	A1A4
W10	102-9300-210	Shaping Board	A1A1
W11	131-0068-001	A1FL3	TNC T (A2A1)
W12	131-0067-001	A1FL4	TNC T (A2A1)
W13	131-0075-001	A2A2	A1FL4
W14	102-9200-502	A2A5	A2J8
W15	102-9200-503	A2J9	A2A7
W16	102-9111-017	A2A7	A2A6
W17	102-9111-009	A2A6	A2A7
W18	102-9200-381	A2A1	A2J1
W19	102-9300-220	A2J1	A2J2
W20	102-9200-502	A2A3	A2J2
W21	102-9200-502	A2A3	A2J3
W22	102-9111-009	A2J3	A2J4
W23	102-9200-503	A2A4	A2J4
W24	102-9200-503	A2A4	A2J5
W25	102-9111-016	A2J5	A3J1
W26	102-9200-422	A3J1	A3A1
W27	102-9200-410	A3A1	A3A2
W28	102-9200-410	A3A3	A3A4
W29	102-9300-225	A3J2	P4-9

CHASSIS ASSEMBLY

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
A1	103-2085-002	Tray Assembly		
A2	103-2079-001	Front Housing Assembly		
A3	103-2060-001	Rear Housing Assembly		
A4	103-2057-001	Pulled Oscillator Assembly		
A5	103-2035-001	Shaping PC Board		
AT1	132-0433-001	RF Input Attenuator		
C1	556-060-146	Capacitor, Ceramic, 0.001μF, 250 V, 40%	71590	DA140-172B
C2	556-060-046	Capacitor, Fixed, Ceramic, 0.001μF, 1K V, 10%	71590	DD-102
C3	150-2002-101FGO	Capacitor, Mica, 100pF, 500 V, 2%	72136	DM15F101G0500 WV4CR
C4	556-120-162	Capacitor, Fixed, Ceramic, 0.1μF, 25 V DC, 20%	56289	5C02310AX0250B3
C5	13-64	Capacitor		
C6	150-5014-001	Capacitor, Elec., 22μF, 20%	56289	1500226X0015B2
CR1	556-147-122	Diode, Zener		
CR2 thru CR5	81-276	Diodes		
J1	168-3002-109	Connector, 56 Contacts, PC Card Type	95238	K600-13PCGD28
J2	168-3007-001	Connector, 10 Contacts, Key Slot, Switching Type	95238	K600-48-6
K1	158-0009-001	Reed Relay		
DS1 thru DS4	160-6010-001	Lamp		
P1 thru P3	556-146-753	Connector, Sub Min, Female, 14 Guide Sockets, Polarized-SST	95238	SM14-20SGD
P4	556-166-045	Connector, Male, 16 Contacts, Polarized Pins	02660	26-159-16
R1	151-1002-823J	Resistor, Fixed, 62KΩ, ±5%, 1/4W	01121	CB6235
R2	151-1002-243J	Resistor, Fixed, 24KΩ, ±5%, 1/4W	01121	CB2435
R3	151-1002-752J	Resistor, Fixed, 7500Ω, ±5%, 1/4W	01121	CB7525
R4	151-1002-222J	Resistor, Fixed, 2200Ω, ±5%, 1 4W	01121	CB2225
R5	151-1002-751J	Resistor, Fixed, 750Ω, ±5%, 1 4W	01121	CB7515
R6	151-1002-301J	Resistor, Fixed, 300Ω, ±5%, 1/4W	01121	CB3015
R7		Switch NOTE: R7 is part of S1, Part No. 133-0165-001		
R8	151-1002-271J	Resistor, Fixed, 270Ω, ±5%, 1/4W	01121	CB2715
R9	151-0047-001	Pot, 2K, 10 Turn		3500S-2-202
R10		Switch Assembly NOTE: R10 is part of S2, Part No. 161-0022-001		
R11	151-1003-561J	Resistor, Fixed, 560Ω, ±5%, 1/2W	01121	EB5615
R12	151-0032-001	Potentiometer, .25K, ±3%	89536	24A-25K Special
R13	151-1002-303J	Resistor, Fixed, 30KΩ, ±5%, 1/4W	01121	CB3035
R14	151-1006-B3092F	Resistor, Fixed, 30900Ω, ±1%, 1/4W	12126	C1/8E30900±1%
R15	151-1006-B1152F	Resistor, Fixed, 11,500Ω, ±1%, 1/4W	12126	C1/8E11500±1%
R16	151-1002-103J	Resistor, Fixed, 10KΩ, ±5%, 1/4W	01121	CB1035
R17	151-1002-512J	Resistor, Fixed, 5100Ω, ±5%, 1/4W	01121	CB5125
R18	151-0046-001	Resistor, Variable		
R19	151-1002-303J	Resistor, Fixed, 30KΩ, ±5%, 1/4W	01121	CB3035

CHASSIS ASSEMBLY (Con't)

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
R20	151-1002-510J	Resistor, Fixed, 51Ω, ±5%, 1/4W	01121	CB5105
R21	151-1002-683J	Resistor, Fixed, 68KΩ, ±5%, 1/4W	01121	CB6835
R22		Switch NOTE: R22 is part of S4 Part No. 133-0163-001		
R23, R24	151-1002-512J	Resistor, Fixed, 5100Ω, ±5%, 1/4W	01121	CB5125
R25	151-1006-B2150F	Resistor, Fixed, 215Ω, ±1%, 1/8W	12126	C1/8E215±1%
R26	151-1006-B3920F	Resistor, Fixed, 392Ω, ±1%, 1/4W	12126	C1/8E392Ω±1%
R27	151-1006-B7870F	Resistor, Fixed, 787Ω, ±1%, 1/4W	12126	C1, 8E787Ω±1%
R28	151-1006-B1651F	Resistor, Fixed, 1650Ω, ±1%, 1/4W	12126	C1 8E1650±1%
R29	151-1006-B5621F	Resistor, Fixed, 5.62K, ±1%, 1/4W	12126	C1, 8E5620Ω±1%
R30		Switch NOTE: R30 it part of S12 Part No. 133-0167-001		
R31	151-1006-B23R7F	Resistor, Fixed, 23.7Ω, ±1%, 1/4W	12126	C1/8E23.7Ω±1%
R32	151-1006-B56R2F	Resistor, Fixed, 56.2Ω, ±1%	12126	C1/8E56.2Ω±1%
R33	151-1006-B1620F	Resistor, Fixed, 162Ω, ±1%, 1/4W	12126	C1 8E162Ω±1%
R34	151-1006-B5900F	Resistor, Fixed, 590Ω, ±1%, 1/4W	12126	C1/8E590Ω±1%
R35	151-1006-B1821F	Resistor, Fixed, 1820Ω, ±1%, 1 4W	12126	C1 8E1820±1%
R36	151-1006-B7681F	Resistor, Fixed, 7.68K ±1%, 1/4 W	12126	C1/8E7680Ω±1%
R37	151-1002-203J	Resistor, Fixed, 20KΩ, ±5%, 1/4 W	01121	CB2035
R40	556-146-516	Resistor, Variable, 1K±30%, 1/2 W	73138	62PR1K
R41, R42	151-0029-500	Resistor, Variable		
R43		Same as R11		
R44	151-0001-053	Resistor, Variable, 500Ω, 1/2 W, Lin, Shaft 1.08FMS	01121	GW7222
R45	151-1002-392J	Resistor, Fixed, Comp., 3.9KΩ, ±5%, 1/4 W	01121	CB3925
S1	103-2111-001	Switch Assembly, Sweep mS/DIV		
S2, S3	161-2112-001	Switch Assembly		
S4	133-2115-001	Switch Assembly		
S6 thru S9	133-0169-001	Switch, Pushbutton		
S10 thru S19	133-0172-001	Switch, Pushbutton		
W1	131-0071-001	Cable Assembly		
W2	102-9300-200	Cable Assembly		
W3	131-0074-001	Cable Assembly		
W8	102-9300-220	Cable Assembly		
W9	131-0070-001	Cable Assembly		
W13	131-0075-001	Cable Assembly		
W25	102-9111-016	Cable Assembly		

TRAY ASSEMBLY

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
A1	132-0421-002	VCO		
A2	134-0065-001	Mixer - Option 4		
A3	103-2051-001	Absol Amp Cal Assembly		
A4	134-0064-001	Mixer - Option 3		
AT1	159-8002-002	Atten., Coax., 10dB, ± 0.5dB, 0.750 Long, Passivated St. Steel	24602	4410
AT2	159-8002-003	Attenuator		
C1, C2, C3, C4	150-5001-251CS	Capacitor, Fixed, Elect., 250µF, +75 -10%, 12 VDC, Insul.	56289	TE-1138
CP1	556-146-995	Adapter, Conn. Rt.Angle, TNC Series Coax.	91737	6017-1
CP2	168-4055-001	Adapter, Coax., TEE, TNC Receps. Anti-Tarnish	91737	6012/Anti-Tarn
CP3	168-4076-001	Adapter, Plug-to-plug, 0.875 LG	26805	2081-0000
CP4	168-4084-001	Adapter		
FL1	103-2081-001	Filter Assembly		
FL2	103-2058-001	Filter Assembly		
FL3	103-1808-001	Absol Amp. Cal. Assembly		
FL4	103-2059-001	Filter Assembly		
FL5	103-2080-001	Filter LP Assembly		
J1	556-146-752	Connector,Plug,Sub.Min.Male, 14 Guide Pins,Polarized SST	95238	SM1420PGD
L1, L2	556-146-700	Inductor,Choke,Shielded,0.50mH, 0.4Ω,30AWG	04213	670-2
W4	102-9300-215	Cable Assembly		
W5	131-0065-001	Cable		
W6	131-0073-001	Cable Assembly		
W7	102-9300-205	Cable Assembly		
W10	102-9300-210	Cable Assembly		
W11	131-0068-001	Cable		
W12	131-0067-001	Cable		

ABSOL AMP CAL ASSEMBLY

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
A1A3A1	103-2039-001	PCBD Assembly AMPCL		
A1A3J1	168-4035-001	Connector,Coax.,Blkhd Jack, CONHEX Series, 50Ω, Snap-On		
A1A3FL1 thru A1A3FL5	556-146-774	Filter, Feedthru,5KpF,200 W VDC, 10A,W/Nut&Lkwshr	72982	1270-016/Nut& Lkwshr

PCBD ASSEMBLY AMPCL

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
C1	150-2002-050CD0	Capacitor, Fixed, Dipped Mica, 5pF, ± 0.5pF, 500 V	72136	DM15C020D0500W V4CR
C2	150-0008-008	Capacitor,Variable,Ceramic,Mini, 9-35pF,N650,PC BD Mtg.	72982	538-011D9-35
C3	556-060-046	Capacitor, Fixed,Ceramic,0.001µF, ±10%,1KVD CW	71590	DD-102
C4		Same as C1		
C5		Same as C2		
C6, C7	150-0008-001	Capacitor,Var.,Ceramic,Mini,2-8 pF, NPO, PC BD Mtg.	72982	538-011A2-8

ASSEMBLY AMPCL (Con't)

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
CR1	556-147-004	Diode, Step Recovery, Silicon, 30 WTV	28480	0112
K1	158-0002-001	Relay, Reed, Miniat, Spdt, 12 VDC, 1300Ω coil, Mag Shield	B	274
L1	156-7007-510	Inductor,Fixed,Molded,51µH, ±5%, 2.85Ω, 235 MA	99800	1537-62
L2	132-0396-001	Inductor		
L3	156-7010-0R1	Inductor,Fixed,Molded,Miniat, 0.10µH, ±10%,0.07Ω, 2K MA	43543	DD-0.10
L4	156-7010-0R47	Inductor,Fixed,Molded,Miniat, 0.47µH, ± 10%,0.35Ω,820 MA	43543	DD-0.47
Q1	556-146-251	Transistor, NPN	INSTD	2N3563
R1	151-1002-113J	Resistor,Fixed,COMP, 11KΩ, ±5%, 1/4W	01121	CB1135
R2	151-1002-152J	Resistor,Fixed,COMP,1500Ω,±5%, 1/4W	01121	CB1525
R3	556-203-010	Resistor,Var,Miniat Trim,PC Perp. Mtg.,500Ω ± 20%, 1/4 W	11236	XHT201-2/500,
R4	556-146-550	Resistor,Var,Miniat Trim,PC Perp. Mtg.,2.5K,±20%, 1/4 W	11236	XHT201-2/2.5K,
R5	151-1002-220J	Resistor,Fixed,COMP,22Ω, ± 5%, 1/4 W	01121	CB2205
R6	151-1002-330J	Resistor,Fixed,COMP,33Ω, ± 5%, 1/4 W	01121	CB3305
R7, R8		Same as R5		
R9		Same as R6		
R10		Same as R5		
R11	151-1002-470J	Resistor, Fixed,COMP,47Ω, ± 5%, 1/4 W	01121	CB4705
R12	151-1002-3R3J	Resistor,Fixed,COMP,3.3Ω, ± 5%, 1/4 W	01121	CB33G5
R13		Same as R11		
R14	151-1002-122J	Resistor,Fixed,COMP,1200Ω, ±5%, 1/4 W	01121	CB1225
Y1	155-0005-001	Crystal,Unit,100.0000 MHz, ±0.005% in HC-18/U Holder	INSTD	CR-56A/U/HC-18 /U Holder

FRONT HOUSING ASSEMBLY A2

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
A1	103-2067-001	Pre-Amp 60 MHz		
A2	103-2037-001	PCBD 1.44 GHz		
A3	103-2045-001	PCBD 60 MHz Fil		
A4	103-2038-001	PCBD 60 MHz Amp		
A5	103-2046-001	PCBD 17 MHz		
A6	103-2040-001	PCBD IF Amp		
A7	103-2041-001	PCBD Ref Osc.		
AT1	159-8002-002	Attenuator,Coax.,10dB, ± 0.5 dB, 0.750 Long Passivated St.Steel	24602	4410
E1	556-009-461	Term, Feed-thru,INS,0.690 LG, 10-32, MTG THG BRS w/Nuts & Lkwshr	95264	6080
FL-1 thru FL-9	556-146-774	Filter,Feed-thru,5KpF,200 WVDC, 10A MAX. w/Nuts & Lkwshr	72982	1270-016/Nut & Lkwshr
J6	168-4058-002	Connector,Cozx.,Recp.,Blkhd, CONHEX Series,50Ω, Screw-on type 12 HEX, 0.668 LG	98291	50-043-0000
J7	170-1026-001	Terminal,Feed-thru,Blkhd,Cap-tured Cntr.Contact,4ACK Solder pot	16179	DSM/211
J10	556-146-752	Connector,Plug,Sub Min,Male, 14 Guide Pins,Polarized-SST	95238	SM14-20 PGD
P1	128-0160-001	Conn., PC BD		
P2	128-0157-001	Conn., PC BD		
P3, P4, P5		Same as P1		

FRONT HOUSING ASSEMBLY A2 (Con't)

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
P6	128-0161-001	Conn., PC BD		
W14	102-9200-502	Cable Assembly		
W15	102-9200-503	Cable Assembly		
W16	102-9111-017	Cable Assembly		
W17	102-9111-009	Cable		
W19	102-9300-220	Cable Assembly		
W20, W21		Same as W14		
W22		Same as W17		
W23, W24		Same as W15		

PRE-AMP 60 MHz ASSEMBLY A2A1

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
A1	103-2036-001	PC BD 60 MHz PA		
A2	103-1761-001	Pre-amp Mixer		
FL1, FL2	556-146-774	Filter, Feed-thru,5KpF,200 WVDC, 10A Max,W/Nut&Lkwshr	72982	1270-016/Nut & Lkwshr
R1	151-1002-103J	Resistor,Fixed,COMP,10KΩ,±5 %, 1/4 W	01121	CB1035
W18	102-9200-381	Cable Assembly		

60 MHz ASSEMBLY A2A1A1

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
C1	150-2002-221FGD	Capacitor,Fixed,DipMica,220pF, ±2%, 500 VDC	72136	DM15F221G0500 WV4CR
C2, C3	150-2002-471FGD	Capacitor,Fixed,DipMica,470pF, ±2%, 500 VDC	72136	DM15471G0500 WV4CR
C4	150-0008-008	Capacitor,Var.,Ceramic,Mini,9-35 pF,N650, PC BD Mtg.<Second Source,JFD Co.,DV1	72982	538-011D9-35
J1-1, J1-2, J1-3	556-146-440	PIN,Pr.Circuit,0.040 IN.DIA by 0.082 IN.LG,SS Hard Gold Plate	71279	2971-2
J2	556-205-001	Connector,Recp.Coax.Hex.,Snap-On Type,0.448 LG,0.155 PIN length,50Ω, Male	98291	51-051-0000
L1	156-7002 011	Inductor,fixed,0.68µH ±20%,0.370 Ω, D,Shielded, 940 MA,0.17	78526	D1NK-0.68
Q1	153-0004-001	Transistor,NPN,RF-AGC,Diff. Silicon Planer	07263	SE 5020
R1	151-1002-103J	Resistor,Fixed,Comp,10KΩ,±5%, 1/4 W	01121	CB1035
R2	151-1002-202J	Resistor,Fixed,Comp,2KΩ,±5%, 1/4 W	01121	CB2025
R3	151-1002-271J	Resistor,Fixed,Comp.,270Ω,±5%, 1/4 W	01121	CB2715
R4		Same as R1		
R5	151-1002-431J	Resistor,Fixed,Comp.,430Ω,±5%, 1/4 W	01121	CB4315
R6	151-1002-120J	Resistor,Fixed,Comp.,12Ω,±5%,	01121	CB1215
R7		Same as R5		
T1	132-0388-001	Transformer		

PRE-AMP MIXER ASSEMBLY A2A1A2

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
CP1	149-0182-001	Connector, Mod.		
CR1	154-0009-001	Diode,Mixer,Schottky,Barrier, S Band	93332	D5501B

1.44 GHz ASSEMBLY A2A2

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
C1	150-2002-560EGO	Capacitor,Fxd,DipMica,56pF, ±2%, 500V	72136	DM15E560G0500 WV4CR
C2	150-2002-431EGO	Capacitor,Fxd,DipMica,430pF, ±2%, 500 VDC	72136	DM15431G0500 WV4CR
C3	150-0008-003	Capacitor,Var.Ceramic,Mini, 2.5-11pF,N300,PCBD Mtg	72982	538-011825-11
C4, C5, C6 C7	556-060-046	Capacitor,Fxd,Ceramic,0.001µF, ±10%,1KVDCW	71590	DD-102
C8	150-2002-070CKO	Capacitor,Fxd,DipMica,7pF,±10% 1KVDCW	72136	DM15C070K0500 WV4CR
C9	150-2002-270EGO	Capacitor,Fxd,Mica,27pF,±2%, 500 VDC	72136	DM15E270G0500 WV4CR
C10,C11	150-2002-150CJO	Capacitor,Fxd,Mica,15pF,±5%, 500 VDC	72136	DM15C150J0500 WV4CR
C12, C13	556-060-146	Capacitor,Ceramic Disc,0.01µF +60 -40%, 250V	71590	DA 140-172B
C14		Same as C3		
C15	150-0008 008	Capacitor,Var,Ceramic,Mini 9-35 pF,N650,PC BD Mtg	72982	538-011D9-35
C16		Same as C9		
C17	150-4001-3R3J	Capacitor,Fxd.Comp.,3.3pF,±5% 500 VDC	78488	GA3.3pF±5%, 500 VDC
C18	150-4001-5R6J	Capacitor,Fxd.Comp,5.6pF,±5% 500V	78488	GA5.6pF±5%
C19	556-005-381	Capacitor,Feed-thru,1KpF,GMV, 500V.Supply with M6447 Washer	01121	FA5C/1KpF W/6447
C20	556-146-697	Capacitor,Ceramic Disc,0.003MFD, GMV,1K VDCW	71590	DD-302
C21		Same as C15		
C22	150-2002-180CJO	Capacitor,Fxd,Mica,18pF,±5%, 500VDC	72136	DM15C180J0500 WV4CR
C23	150-0008-001	Capacitor,Var.,Ceramic,Mini., 208pF,NPO PC BD Mtg	72982	538-011A2-8
CR1	556-147-004	Diode,Step Recovery,Silicon, 30 WIV	28480	0112
J1-1, J1-2, J1-3	556-146-440	Post,PIN,PC,0.040 IN.DIA by 0.082 IN.LG SS Hard Gold Plate	71279	2971-2
L1	132-0390-001	Inductor		
L2	556-146-420	Inductor,Choke,Molded,2.2µH, ±10%	82142	4436-4K
L3	132-0391-001	Inductor		
L4	132-0392-001	Inductor		
L5	132-0377-003	Inductor		
L6, L7, L8	156-7002-005	Inductor,Fxd, 0.22µH,±20%,0.045Ω, 2700MA,0.17D,Shielded	78526	D1NK-0.22
L9	132-0393-001	Inductor		
L10	132-0394-001	Inductor		
L11		Same as L5		
L12	156-7004-007	Inductor,RF,Molded Mini,0.33µH, ±10%	82142	4416-7
L13	132-0395-001	Inductor		
L14		Same as L6		
Q1	556-146-251	Transistor, NPN	INSTD	2N3563
Q2	556-146-702	Transistor,0.330 DIA,3 leads, 0.400 LG	INSTD	2N3642
Q3	153-3015-001	Transistor,NPN,Silicon,Hi-speed SW&RF Amp, to -5 Case	07263	2N3299
Q4	556-146-679	Transistor	INSTD	2N3866
R1	151-1002-912J	Resistor,Fxd,Comp.,9.1KΩ,±5%, 1/4 W	01121	CB9125
R2	151-1002-472J	Resistor,Fxd,Comp.,4700Ω,±5% 1/4 W	01121	CB4725
R3	151-1002-221J	Resistor,Fxd,Comp.,220Ω,±5% 1/4 W	01121	CB2215
R4	151-1003-100J	Resistor,Fxd,Comp.,10Ω,±5% 1/2 W	01121	EB1005
R5	151-1002-392J	Resistor,Fxd,Comp.,3.9KΩ,±5% 1/4 W	01121	CB3925

1.44 GHz ASSEMBLY A2A2 (Con't)

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
R6	151-1002-121J	Resistor,Fxd,Comp.,120Ω,±5%, 1/4 W	01121	CB1215
R7		Same as R4		
R8	151-1002-150J	Resistor,Fxd,Comp.,15Ω, ±5% 1/4 W	01121	CB1505
R9	151-1002-680J	Resistor,Fxd,Comp,68Ω,±5% 1/4 W	01121	CB6805
R10		Same as R8		
R11	151-1005-101J	Resistor,Fxd,Comp,100Ω,±5% 2 W	01121	HB1025
R12	151-1002-511J	Resistor,Fxd,Comp.510Ω,±5% 1/4 W	01121	CB5115
R13	151-1004-510J	Resistor,Fxd,Comp.51Ω,±5% 1 W	01121	GB5105
R14	151-1005-510J	Resistor,Fxed,Comp.51Ω,±5% 2 W	01121	HB5105
R15	151-1002-8R2J	Resistor,Fxd,Comp,8.2Ω,±5% 1/4 W	01121	CB82G5
R16	151-1002-151J	Resistor,Fxd,Comp,150Ω,±5% 1/4 W	01121	CB1515
R17		Same as R15		
T1	132-0389-001	Transformer		
Y1	155-0004-001	Crystal,Unit,100.0000MHz, ±0.005%, IN HC-18/U Holder	INSTD	CR-57A/U/ HC-18/U Holder

60 MHz FILTER ASSEMBLY A2A3

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
C1	150-2002-560EGC	Capacitor,Fxd,Dip Mica,56pF, ±2%, 500V	72136	DM15E560G0500 WV4CR
C2	150-4001-3R3J	Capacitor,Fxd,Comp.,3.3pF, ±5%, 500VDC	78488	GA3.3pF±5% 500VDC
C3	150-2006-001	Capacitor		
C4		Same as C2		
C5		Same as C3		
C6		Same as C2		
C7		Same as C1		
J1, J2	556-205-001	Connector,Recp.Coax.Hex,Snap-on Type,0.448LG,0.155 PIN length,50Ω, Male	98291	51-051-0000
L1, L2	132-0410-001	Inductor, Var.		
T1, T2	132-0231-001	Transformer		

60 MHz AMP ASSEMBLY A2A4

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
C1, C2	556-060-046	Capacitor,Fxed,Ceramic,0.001µF, ±10%,1K VDCW	71590	DD-102
C3	150-2002-220EJO	Capacitor,Fxd,DipMica,200pF, ±5%,500V	72136	DM15F201J0500 WV4CR
C4	150-2002-151FGO	Capacitor,Fxd,DipMica,150pF, ±2%,500V	72136	DM15F151G0500 WV4CR
C5, C6, C7		Same as C1		
C8	150-2002-330EGO	Capacitor,Fxd,Mica,33pF, ±2%,500V	72136	DM15E330G0500 WV4CR
C9		Same as C1		
C10		Same as C4		
C11		Same as C1		
C12	150-2002-560EGO	Capacitor,Fxd,Mica,56pF,±2%, 500V	72136	DM15E560G0500 WV4CR
C13		Same as C1		
C14	150-2002 101FGO	Capacitor,Fxed,DipMica,100pF, ±2%,500V	72136	DM15F101G0500 WV4CR
HR1	149-0234-001	Oven,Tstr.,Mod.		
J1, J2,	556-205-001	Connector,Recp.Coax,Hex,Snap-on Type,0.448LG,0.155 PIN Length,50Ω,Male	98291	51-051-0000

60 MHz AMP ASSEMBLY A2A4 (Con't)

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
J3-1, J3-2, J3-3, J3-4	556-146-440	Post,PIN,PC,0.040,IN.DIA.by0.082 IN.LG SS Hard Gold Plate	71279	2971-2
L1	556-012-198	Choke,RF,0.33µH,±10%	82142	4416-7
L2	132-0437-001	Inductor,Var.		
L3	156-7002-022	Inductor,Fxd,5.6µH,±10%,0.640Ω, 710MA,0.17D,Shielded	78526	DINK-5.6
L4	132-0438-001	Inductor,Var.		
L5		Same as L3		
L6	132-0439-001	Inductor		
Q1	556-146-739	Transistor,Diff,Silicon Planar	07263	2N4134
Q2	153-0004-001	Transistor,NPN,RF-AGC,Diff, Silicon Planar	07263	SE5020
Q3	556-146-251	Transistor, NPN	INSTD	2N3563
R1	151-1002-101J	Resistor,Fxd,Comp.100Ω,±5%,1/4W	01121	CB1015
R2, R3	151-1002-302J	Resistor,Fxd,Comp., 3KΩ,±5%, 1/4 W	01121	CB3025
R4	151-1002-332J	Resistor,Fxd,Comp ,3300Ω,±5%, 1 4 W	01121	CB3325
R5	151-1002-561J	Resistor,Fxd,Comp,560Ω,±5%,	01121	CB5615
R6	151-1002-681J	Resistor,Fxd,Comp.,680Ω,±5%, 1/4 W	01121	CB6815
R7	151-1002-911J	Resistor,Fxd,Comp.,910Ω,±5%, 1/4 W	01121	CB9115
R8, R9		Same as R2		
R10	151-1002-102J	Resistor,Fxd,Comp.,1KΩ,±5%, 1/4 W	01121	CB1025
R11	556-146-558	Resistor,Var.100Ω,±30%, 1-1/2 W	73138	62PR100
R12	151-1002-510J	Resistor,Fxd,Comp,51Ω,±5%, 1/4 W	01121	CB5105

17 MHz ASSEMBLY A2A5

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
C1	556-060-146	Capacitor,Ceramic Disc,0.01µF, +60 -40%, 250V	71590	DA140-172B
C2	556-060-046	Capacitor,Fxd,Ceramic,0.001µF, ±10%,1K VDCW	71590	DD-102
C3	150-0008-002	Capacitor,Var,Ceramic,Mini,5.5 to 18pF,NPO,PC BD Mtg	72982	538-011A5.5-18
C4		Same as C1		
CR1	556-147-187	Diode, Step Recovery	88236	VAS-11BEP
J1	556-205-001	Connector,Recp.Coax,Hex,Snap-on Type,0.448 LG,0.155 PIN Length,50Ω,Male	98291	51-051-0000
J2-1, J2-2, J2-3	556-146-440	Post,PIN,Pr.Circuit,0.040 IN.DIA by 0.082 IN.LG SS Hard Gold Plate	71279	2971-2
L1	156-7002-025	Inductor,Fxd,10µH,±10%,1.40Ω, 480 MA,0.17D,Shielded	78526	DINK-10
Q1	556-147-003	Transistor	86684	2N4427
R1, R2	151-1002-150J	Resistor,Fxd,Comp,150Ω,±5%, 1/4 W	01121	CB1505
R3	151-1002-680J	Resistor,Fxd,Comp,68Ω,±5%, 1/4 W	01121	CB6805
R4	151-1003-512J	Resistor,Fxd,Comp,5100Ω,±5%, 1/2 W	01121	EB5125
R5	151-1003-102J	Resistor,Fxd,Comp,1KΩ,±5%, 1/2 W	01121	EB1025
R6	151-1004-220J	Resistor,Fxd,Comp,22Ω,±5%,1 W	01121	GB2205
R7	151-1002-510J	Resistor,Fxd,Comp,51Ω,±5%, 1/4 W	01121	CB5105
R8	151-1002-820J	Resistor,Fxd,Comp,82Ω,±5%, 1/4 W	01121	CB8205
R9	151-1002-151J	Resistor,Fxd,Comp,150Ω,±5% 1/4 W	01121	CB1515

17 MHz ASSEMBLY A2A5 (Con't)

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
R10		Same as R8		
T1	132-0310-001	Transformer, T1		

PC BD IF AMP, 11.85 MHz ASSEMBLY A2A6

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
AR1	153-7012-001	Amplifier, I.C.,Operational,Wide-band,MetalCan,12V	02713	MC1712CG
C1, [illegible]	556-060-146	Capacitor,Ceramic Disc,0.01μF, +60 -40%, 250V	71590	DA140-1728
C3	150-2002-750EGO	Capacitor,Fxd,Mica,75pF,±2%, 500 VDC	72136	DM15E750G0500 WV4CR
C4	150-2002-331FJO	Capacitor,Fxd,DipMica,330pF,±5% 500 V	72136	DM15F331J0500 WV4CR
C5, C6, C7, C8	556-120-162	Capacitor,Fxd,Ceramic,0.1μF ±20%,25 VDC	56289	5C02310AX0250B3
C9		Same as C1		
C10		Same as C5		
E1, E2	556-146-440	Post,PIN,Pr.Circuit,0.040 IN.DIA by 0.082 IN.LG SS Hard Gold Plate	71279	2971-2
J1, J2	556-205-001	Connector,Recp.Coax,Hex,Snap-on Type,0.448 LG 0.155 PIN Length,50Ω,Male	98291	51-051-0000
L1	132-1423-001	Inductor,Val.		
Q1	153-0007-001	Transistor,NPN,Silicon Planar	73445	A467
R1	151-1002-103J	Resistor,Fxd,Comp,10KΩ,±5%, 1/4 W	01121	CB1035
R2	151-1002-512J	Resistor,Fxd,Comp,5100Ω,±5%, 1/4 W	01121	CB5125
R3, R4	151-1002-102J	Resistor,Fxd,Comp,1KΩ,±5%, 1/4 W	01121	CB1025
R5	151-1002-510J	Resistor,Fxd,Comp,51Ω,±5%, 1/4 W	01121	CB5105
R6		Same as R3		
R7	151-1002-100J	Resistor,Fxd,Comp,10Ω,±5%, 1/4 W	01121	CB1005
R8	151-1002-271J	Resistor,Fxd,Comp,270Ω,±5%, 1/4 W	01121	CB2715

REF OSC ASSEMBLY A2A7

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR PART NO.
C1	150-2002-221FJO	Capacitor,Fxd,DMca,220pF,±2%, 500 VDC	72136	DM15F221G0500 WV4CR
C2	150-2002-101FJO	Capacitor,Fxd,DMca,100pF,±2%, 500 V	72136	DM15F101G0500 WV4CR
C3, C4	556-060-146	Capacitor, Ceramic Disc,0.01μF, +60 -40%, 250 V	71590	DA140-1728
C5, C7	150-2002-271FJO	Capacitor,Fxd,DMca,270pF,±2%, 500 V	72136	DM15F271G0500 WV4CR
C6	150-2002-270FJO	Capacitor,Fxd,DMca,27pF,±2%, 500 V	72136	DM15F270G0500 WV4CR
CR1, CR2, CR3, CR4	154-0005-001	Diode, Quad.	16068	Q4-600
J1, J2, J3	556-205 001	Connector,Recp.Coax,Hex,Snap-on Type,0.448 LG 0.155 PIN Length,50Ω, Male	98291	51-051-0000
J4-1, J4-2, J4-3	556-146-440	Post,PIN,PC,0.040,IN.DIA by 0.082 IN.LG SS Hard Gold Plate	71279	2971-2
Q1	556-146-256	Transistor	INSTD	2N3646
R1	151-1002-392J	Resistor,Fxd,Comp.3.9KΩ,±5%, 1/4 W	01121	CB3925
R2	151-1002-822J	Resistor,Fxd,Comp,8200Ω,±5%, 1/4 W	01121	CB8225
R3	151-1002-471J	Resistor,Fxd,Comp,470Ω,±5%, 1/4 W	01121	CB4715
R4	151-1002-331J	Resistor,Fxd,Comp,330Ω, ±5%, 1/4 W	01121	CB3315

REF OSC ASSEMBLY A2A7 (Con't)

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
R5	151-1002-430J	Resistor,Fxd,Comp,43Ω,±5%, 1/4 W	01121	CB4305
R6	151-1002-100J	Resistor,Fxd,Comp,10Ω, ±5%, 1/4 W	01121	CB1005
R7		Same as R5		
R8		Same as R6		
R9	151-1002-202J	Resistor,Fxd,Comp,2KΩ, ±5%, 1/4 W	01121	CB2025
T1	132-0424-001	Inductor		
T2, T3	132-0412-001	Transformer		
T4, T5	132-0436-001	Inductor		
Y1	155-0007-001	Crystal Unit,Quartz,11.850MHz, in HC-18/U Holder	74306	4201

REAR HOUSING ASSEMBLY A3

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
A1	103-2033-001	PC BD, Swept L.O.		
A2	103-2034-001	PC BD, NB Filter		
A3	103-2032-001	PC BD, B. W. Amp		
A4	103-2031-001	PC BD, LOG-LIN		
C1, C2	556-060-071	Capacitor,Fxd,Ceramic Feed-thru 1K/F, ±20%, 500 VDC, W/Nut & Lkwshr.	72982	2443-000 X 550 102 M/Hdwe
C3, C4	556-202-001	Capacitor,Feed-thru,0.02μF,+80 -20%,3/8-32 NEF - 2A THD	56289	533C14A
C5, C6, C7		Same as C1		
C8		Same as C3		
C10, C11		Same as C3		
C12, C13, C14		Same as C1		
C15		Same as C3		
C16, C17, C18		Same as C1		
C19, C20, C21, C22, C23, C24, C25	556-120-160	Capacitor,Fxd,Ceramic,0.47μF, ±20%, 25 VDC	56289	5C11
E1	556-009-461	Terminal,Feed-thru,Ins.,0.690 LG, 10-32,Mtg.Thd.,Brs. with Nut & Lkwshr.	95264	6080
E2, E3	135-0119-001	Feed-thru Assembly		
J3	556-146-752	Connector,Plug,SubMin,Male,14 Guide Pins,Polarized-SST	95238	SM14-20PGD
P1, P2	128-0159-001	Connector, PC BD, 6 Pin		
P3	128-0158-001	Connector, PC BD, 3 Pin		
P4	128-0157-001	Connector, PC BD		
P5		Same as P1		
W26	102-9200-422	Cable Assembly		
W27, W28	102-9200-410	Cable Assembly		

SWEPT L.O. ASSEMBLY A3A1

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
A1	556-146-992	Amplifier,Operational,Integ.Ckt.	07263	UA709C U5B7709 39X
C1	556-146-697	Capacitor,CeramicDisc,0.003 MFD GMV,1K VCDW	71590	DD-302
C2	150-2002-201FGO	Capacitor,Fxd, D.Mca,200pF, ±2%, 500 V	72136	DM15F201G0500 WV4CR
C3, C4, C5, C6	556-120-160	Capacitor,Ceramic,0.47μF ±20%, 25VDC	56289	5C11

SWEPT L.O. ASSEMBLY A3 A1 (Con't)

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
C7	556-060-146	Capacitor,Ceramic Disc,0.01µF +60 -40%, 250 V	71590	DA140-172B
C8, C9, C10	150-2002 120CJO	Capacitor,Fxd,Mica,12pF,±5%, 500 VDC	72136	DM15C120J0500 WV4CR
C11	150-2002-150CJO	Capacitor,Fxd,Mica,15pF,±5%, 500 VDC	72136	DM15C150J0500 WV4CR
C12	150-2002-820EGO	Capacitor,Fxd,Mica,82pF,±2%, 500 VDC	72136	DM15E820G0500 WV4CR
C13	556-120-162	Capacitor, Fixed,Ceramic,0.47µF, ±20%, 25 VDC	56289	5C11
C14	150-5001-4R0HS	Capacitor,Fxd,Elect,4µF, +75 -10%, 150 VDC, Insul.	56289	TE-1503
C15	556-146-921	Capacitor,Fxd,MetPlasticFilm,Min 0.10µF,±10%, 250 VDCW	25088	B32231-A3104K
C16		Same as C3		
C17	150-2002-271FGO	Capacitor,Fxd,D.Mica,270pF,±2%, 500 V	72136	DM15F271G0500 WV4CR
C18	150-2003-302FJO	Capacitor,Fxd,Mca,3KpF,±2%, 500 VDC	72136	DM19F302G0500 WV4CR
C19	150-0008-008	Capacitor,Var,Ceramic,Mini 9-35pF,N650 PC BD Mtg.	72982	538-011D9-35
C20	150-2002-391FGO	Capacitor,Fxd,D.Mca,390pF, ±2%, 500 VDC	72136	DM15F391G0500 WV4CR
C21	150-2003-132FGO	Capacitor,Fxd,D.Mca,1300pF, ±2%, 500 VDC	72136	DM19F132G 500WV4CR
C22	150-2002-300EGO	Capacitor,Fxd,Mica,30pF,±5%, 500 V	72136	DM15F300G0500 WV4CR
C23		Same as C17		
C24		Same as C19		
C25		Same as C13		
C26		Same as C3		
C27	150-2002-131FGO	Capacitor,Fxed,D.Mca,131pF,±5%, 500 V	72136	DM15F131J0500 WV4CR
C28		Same as C19		
C29		Same as C17		
C30		Same as C13		
C31		Same as C3		
C32	150-2002-621FJO	Capacitor,Fxd,D.Mca,620pF, ±5%, 500 V	72136	DM15F621J0500 WV4CR
C33		Same as C13		
C34		Same as C7		
CR1	556-146-880	Diode, Switching, Silicon,25WIV, 4. ONS Recovery	07263	FDH-666
CR3	556-146-095	Capacitor,Var,Voltage,47pF at 4 VDC, 80 VDC Max.	19373	VC347
CR4, CR5, CR6, CR7	154-0005-001	Diode,Matched,Quad.	16068	Q4-600
J1-1, J1-2, J1-3, J1-4, J1-5, J1-6	556-146-440	Post,PIN,PC,0.040,IN.DIA by 0.082 IN.LG SS, Hard Gold Plate	71279	2971-2
J2, J3	556-024-272	Jack, Phono	83330	1233
L1, L2, L3	156-7002-041	Inductor,Fxd,220µH,±5% 4.10Ω, 280 MA-0.17 D,Shielded	78526	DINK-220
L4	556-146-700	Choke,Shielded,0.50 mH,0.4Ω, 30 AWG,M 10%,1/4 D x 1/2 LG	04213	670-2
L5	132-0229-001	Inductor		
L6	156-7002-030	Inductor,Fxd,27µH,±5%,1.15Ω, 530 MA,0.17 D, Shielded	78526	DINK-27
L7		Same as L1		
L8	156-7002-014	Inductor,Fxd,1.2µH,±10%,0.067Ω, 2200 MA, 0.17 D, Shielded	78526	DINK-1.2
L9, L10	156-7002-025	Inductor,Fxd,10µH,±10%,1.40Ω, 480 MA,0.17 D, Shielded	78526	DINK-10
L11	556-012-201	Choke, R.F.,22µH, ±10%	82142	1316-4
L12		Same as L1		
L13	156-7002-022	Inductor,Fxd,5.6µH,±10%,0.640Ω, 710 MA,0.17 D, Shielded	78526	DINK-5.6
Q1	556-146-401	Transistor	INSTD	2N3638A
Q2	153-3023-001	Transistor,PNP,Diffused Silicon Planar, 150V	07263	2N4889
Q3, Q4, Q5	556-146-251	Transistor, NPN	INSTD	2N3563

SWEPT L.O. ASSEMBLY A3A1 (Con't)

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
R1	151-1002-203J	Resistor,Fxd,Comp,20KΩ,±5%, 1/4 W	01121	CB2035
R2	151-1002-103J	Resistor,Fxd,Comp,10KΩ,±5%, 1/4 W	01121	CB1035
R3	556-203-006	Resistor,Var.MiniatTrim,PCPerp Mtg.25K,±20%,1/4 W	11236	XHT201-2/25K, 20%
R4	151-1002-333J	Resistor,Fxd,Comp,33KΩ,±5%, 1/4 W	01121	CB3335
R5		Same as R2		
R6	151-1002-152J	Resistor,Fxd,Comp,1500Ω,±5%, 1 4 W	01121	CB1525
R7	556-056-129	Resistor,Var,MiniatTrim,PC Perp Mtg.50K,±20%,1/4 W	11236	XHT201-2/50K, 20%
R8		Same as R1		
R9		Same as R4		
R10	151-1003-913J	Resistor,Fxd,Comp,91KΩ, ±5%, 1/2 W	01121	CB1825
R11	151-1002-182J	Resistor,Fxd,Comp,1800Ω, ±5%, 1 4 W	01121	CB1825
R12	556-056-28	Resistor,Var,MiniatTrim,PC Perp Mtg.100K, ±20%, 1/4 W	11236	XHT201-2/100K, 20%
R13	556-146-541	Resistor,Var,MiniatTrim, PC Perp Mtg., 5K, ±20%, 1/4 W	11236	XHT201-2/5K, 20%
R14	151-1003-682J	Resistor,Fxd,Comp.6800Ω, ±5%, 1/2 W	01121	EB6825
R15	151-1002-102J	Resistor,Fxd,Comp,1KΩ, ±5%, 1/4 W	01121	CB1025
R16	151-1002-104J	Resistor,Fxd,Comp,100KΩ, ±5%, 1/4 W	01121	CB1045
R17	151-1002-184J	Resistor,Fxd,Comp,180KΩ, ±5%, 1/4 W	01121	CB1845
R18	151-1002-431J	Resistor,Fxd,Comp,430Ω, ±5%, 1/4 W	01121	CB4315
R19	151-1002-682J	Resistor,Fxd,Comp,6800Ω, ±5%, 1/4 W	01121	CB6825
R20		Same as R15		
R21	151-1002-362J	Resistor,Fxd,Comp,3600Ω, ±5%, 1/4 W	01121	CB3625
R23, R24	151-1002-302J	Resistor,Fxd,Comp,3KΩ. ±5%, 1/4 W	01121	CB3025
R25		Same as R15		
R26		Same as R23		
R27	151-1002-202J	Resistor,Fxd,Comp,2KΩ, ±5%, 1 4 W	01121	CB2025
R28	151-1002-101J	Resistor,Fxd,Comp,100Ω, ±5%, 1/4 W	01121	CB1015
R29		Same as R15		
R30	151-1002-180J	Resistor,Fxd,Comp,18Ω, ±5%, 1/4 W	01121	CB1805
R31, R32	151-1002-301J	Resistor,Fxd,Comp,300Ω, ±5%, 1/4 W	01121	CB3015
RV1	151-5003-001	Varistor,1.0 MA at 36 VDC,±15%, Ratio 1.80 Max,Red Glyptol Dip Coat, Lea,DLength,1.250 Mac - from bottom of body	10646	613-BNR-2-042
T1, T2	132-0412-001	Transformer Assembly		

NB FILTER ASSEMBLY A3A2

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
C1, C2, C3, C4, C5	556-120-162	Capacitor,Fxd,Ceramic,0.1µF, ±20%,25VDC	56289	5C02310AX0250B3
C6	150-2002-331FJO	Capacitor,Fxd,D.Mca,330pF,±5%, 500V	72136	DM15F331J0500 WV4CR
C7	556-122-065	Capacitor,Var,Ceramic,Trim8-50 pF,N750,350V	72982	557-091U2P034R
C8	150-4001-3R9K	Capacitor,Fxd,Comp.3.9pF,±10%, 500VDC	78488	GA3.9pF±10%
C9		Same as C6		
C10		Same as C7		
C11		Same as C8		
C12		Same as C6		
C13		Same as C7		
C14		Same as C8		

NB FILTER ASSEMBLY A3A2 (Con't)

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
C15		Same as C6		
C16		Same as C7		
C17, C18, C19, C20, C21	556-120-160	Capacitor,Fxd,Ceramic,0.47μF, ±20%,25VDC	56289	5C11
CR1, CR2, CR3, CR4	556-118-046	Diode,Switching,Silicon,40 PIV	93332	1N251
J1-1, J1-2, J5-1, J5-2, J5-3	556-146-440	Post,PIN,PC,0.040 IN.DIA by 0.082 IN.LG SS Hard Gold Plate	71279	2971-2
J2, J4	173-8006-001	Pin,Socket,Miniature,0.375 LG Gold Plated	06776	PS-40-101/Gold Plated
J3	556-024-272	Jack, Phono	83330	1233
L1, L2, L3, L4	156-7002-025	Inductor,Fxd,10μH,±10%,1.40Ω, 480 MA,0.17D,Shielded	78526	DINK-10
L5, L6, L7	156-7002-041	Inductor,Fxd,220μH,±5%,4.10Ω, 280 MA,0.17D, Shielded	78526	DINK-220
Q1, Q2	556-146-251	Transistor, NPN	INSTD	2N3563
R1	151-1002-102J	Resistor,Fxd,Comp,1KΩ,±5%, 1/4 W	01121	CB1025
R2, R3	151-1002-152J	Resistor,Fxd,Comp,1500Ω,±5%, 1/4 W	01121	CB1525
R4		Same as R1		
R5, R6	151-1002-103J	Resistor,Fxd,Comp,10KΩ,±5%, 1/4 W	01121	CB1035
R7	151-1002-203J	Resistor,Fxd,Comp,20KΩ,±5%, 1/4 W	01121	CB2035
R8	151-1002-511J	Resistor,Fxed,Comp,510Ω,±5%, 1/4 W	01121	CB5115
R9	151-1002-182J	Resistor,Fxd,Comp,1800Ω,±5%, 1/4 W	01121	CB1825
R10		Same as R7		
R11	151-1002-101J	Resistor,Fxd,Comp,100Ω,±5%, 1/4 W	01121	CB1015
R12		Same as R1		

B.W. AMP ASSEMBLY A3A3

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR PART NO.
C1	556-120-162	Capacitor,Fxd,Ceramic,0.1μF, ±20%,25VDC	56289	5C02310AX025 0B3
C2	556-120-160	Capacitor,Fxd,Ceramic,0.47μF, ±20%, 25 VDC	56289	5C11
C3, C4		Same as C1		
C5		Same as C2		
C6	150-0008-003	Capacitor,Var,Ceramic,Mini,2.5 to 11pF,N300,PC BD Mtg	72982	538-011B2.5-11
C7	150-0008-002	Capacitor,Var,Ceramic,Mini,5.5 to 18pF, NPO, PC BD Mtg	72982	538-0ppA5.5-18
C8	150-1001-820J	Capacitor,Fxd,DiscCeromic,82pF, 500V	72982	851-000U2J0820J
C9	150-4009-001	Capacitor,Fxd,Mylar.01μF,±10%, 100V	81349	CK05BX103K
C10		Same as C2		
C11	150-4008-001	Capacitor,Fxd,Mylar.001μF, ±10%,100V	81349	CK05BX102K
C12	150-2002-201FGO	Capacitor,Fxd,D.Mca,200pF, ±2%,500V	72136	DM15F201G0500 WV4CR
C13, C14		Same as C9		
C15		Same as C1		
C16	150-2002-561FJO	Capacitor,Fxd,Mica,200pF,±2%, 500V	72136	DM15F201J0500 WV4CR
C17	150-0008-008	Capacitor,Var,Ceramic,Mini, 9-35pF,N650,PC BD Mtg	72982	538-001D9-35
C18,C19		Same as C1		
C20		Same as C6		
C21		Same as C7		
C22		Same as C2		
C23		Same as C8		
C24		Same as C9		
C25		Same as C2		
C26		Same as C11		

B.W. AMP ASSEMBLY A3A3 (Con't)

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
C27		Same as C12		
C28		Same as C9		
C29		Same as C2		
C30		Same as C1		
C31		Same as C2		
C33		Same as C1		
C34		Same as C2		
C35, C36		Same as C1		
C37, C38, C39		Same as C2		
CR1, CR2, CR3, CR4	556-118-046	Diode, Switching, Silicon, 40 PIV	93332	1N251
J1	173-8006-001	Pin,Socket,Miniature,0.375 LG, Gold Plated	06776	PS-40-1011 Gold Plated
J2	556-024-272	Jack, Phono	83330	1233
J3		Same as J1		
J4-1, J4-2, J4-3, J4-4, J4-5, J4-6	556-146-440	Post,PIN,PC,0.040 IN.DIA by 0.082 IN.LG SS Hard Gold Plate	71279	2971-2
L1, L2	156-7002-041	Inductor,Fxd,220μH,±5%,4.10Ω, 280 MA,0.17D, Shielded	78526	DINK-220
L3	132-0422 001	Inductor, Var.		
L4	156-7002-022	Inductor,Fxd,5.6μH,±10%,0.640Ω, 710 MA,0.17D, Shielded	78526	DINK-5.6
L5, L6		Same as L1		
L7		Same as L3		
L8, L9, L10		Same as L1		
MC1, MC2	556-146-992	Integ Ckt, Operational Amplifier	07263	UA709C/U5B 770939X
Q1, Q2	556-146-672	Transistor	INSTD	2N3015
Q3	556-146-675	Transistor	INSTD	2N3641
Q4	153-3022-001	Transistor	INSTD	2N4360
Q5, Q6	556-146-677	Transistor	INSTD	2N3694
Q7		Same as Q4		
Q8		Same as Q5		
Q9		Same as Q3		
R1	151-1002-101J	Resistor,Fxd,Comp,100Ω,±5%, 1/4 W	01121	CB1015
R2, R3	151-1002-242J	Resistor,Fxd,Comp,2400Ω, ±5%, 1/4 W	01121	CB2425
R4	151-1002-102J	Resistor,Fxd,Comp,1KΩ,±5%, 1/4 W	01121	CB1025
R5	151-1002-152J	Resistor,Fxd,Comp,1500Ω,±5%, 1/4 W	01121	CB1525
R6		Same as R1		
R7	151-1003-392J	Resistor,Fxd,Comp,3.9KΩ,±5%, 1/2 W	01121	EB3925
R8		Same as R4		
R9	151-1004-271J	Resistor,Fxd,Comp,270Ω,±5%, 1 W	01121	GB2715
R10	151-1004-181J	Resistor,Fxd,Comp,180Ω, ±5%, 1 W	01121	GB1815
R11	151-1002-104J	Resistor,Fxd,Comp,100KΩ, ±5%, 1/4 W	01121	CB1045
R12	151-0040-001	Resistor,Var,Linear,250K ±30%, 19/32 IN.DIA .500 VDC,1/4 W	11236	XHT-201-2 250K
R13		Same as R5		
R14		Same as R1		
R15	151-1002-333J	Resistor,Fxd,Comp,33KΩ,±5%, 1/4 W	01121	CB3335
R16		Same as R11		
R17		Same as R2		
R18		Same as R4		
R19	151-1002-113J	Resistor,Fxd,Comp,11KΩ,±5%, 1/4 W	01121	CB1135
R20	151-1002-123J	Resistor,Fxd,Comp,12KΩ,±5%, 1/4 W	01121	CB1235

B.W. AMP ASSEMBLY A3A4 (Con't)

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
R21		Same as R4		
R22	151-1002-820J	Resistor,Fxd,Comp,82Ω,±5%, 1/4 W	01121	CB8205
R23	556-203-010	Resistor,Var,MiniatTrim.PC Perp Mtg,500Ω,±20%, 1/4 W	11236	XHT201-2/500, 20%
R24	151-1002-302J	Resistor,Fxd,Comp,3KΩ,±5%, 1/4 W	01121	CB3025
R25	151-1002-681J	Resistor,Fxd,Comp,680Ω,±5%, 1/4 W	01121	CB6815
R26	151-1002-271J	Resistor,Fxd,Comp,270Ω,±5%, 1/4 W	01121	CB2715
R27	151-1002-181J	Resistor,Fxd,Comp,180Ω,±5%, 1/4 W	01121	CB1815
R28	151-1003 122J	Resistor,Fxd,Comp,1200Ω,±5%, 1/2 W	01121	EB1225
R29		Same as R11		
R30		Same as R12		
R31		Same as R5		
R32		Same as R1		
R33		Same as R5		
R34		Same as R4		
R35		Same as R2		
R36	151-1002-122J	Resistor,Fxd,Comp,1200Ω,±5%, 1/4 W	01121	CB1225
R37		Same as R2		
R38		Same as R36		
R39		Same as R1		
VCR1, VCR2	556-146-747	Raysistor,4Pin,0.735W,0.310 Contact Length,0.350 TK,Photo	94144	CK1121
Y1, Y2	556-146-593	Crystal,Pair,2.7MHz,Each Crystal in HC-6/U Holder	74306	508-02-37

PC BD LOG LIN ASSEMBLY A3A4

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
C1	556-060-146	Capacitor,CeramicDisc,0.01μF, -60 -40%, 250V	71590	DA 140-172B
C2	150-2003-202FJO	Capacitor,Fxd,Mca,2KpF,±5%, 500 VDC	72136	DM19F202J0500 WV4CR
C3	556-120-160	Capacitor,Fxd,Ceramic,0.47μF ±20%, 25 VDC	56289	5C11
C4	150-2002-621FJO	Capacitor,Fxd,D.Mca,620pF, ±5%,500V	72136	DM15F621J0500 WV4CR
C5	150-0008-008	Capacitor,Var,Ceramic,Mini, 9-35pF,N650, PC BD Mtg	72936	538-011D9-35
C6		Same as C1		
C7		Same as C2		
C8		Same as C3		
C9	150-2002-180CJO	Capacitor,Fxd,Mca,18pF,±5%, 500V	72136	DM15C180J0500 WV4CR
C10		Same as C4		
C11		Same as C5		
C12	150-2002-201FGO	Capacitor,Fxd,D.Mca,200pF, ±2%, 500V	72136	DM15F201G0500 WV4CR
C13		Same as C1		
C14		Same as C2		
C15		Same as C3		
C16	150-2002-360EGO	Capacitor,Fxd,D.Mca,36pF,±2%, 500 VDC	72136	DM15E360G0500 WV4CR
C17		Same as C4		
C18		Same as C5		
C19		Same as C12		
C20		Same as C1		
C21		Same as C2		
C22		Same as C3		
C23		Same as C16		
C24		Same as C4		
C25		Same as C5		
C26		Same as C12		
C27		Same as C1		
C28		Same as C2		

LOG/LIN ASSEMBLY A3 A4 (Con't)

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
C29		Same as C3		
C30		Same as C16		
C31		Same as C4		
C32		Same as C5		
C33		Same as C3		
C34		Same as C12		
C35		Same as C1		
C36		Same as C3		
C37		Same as C2		
C38		Same as C3		
C39		Same as C16		
C40		Same as C4		
C41		Same as C5		
C42		Same as C12		
C43		Same as C1		
C44		Same as C2		
C45, C46		Same as C3		
C47		Same as C16		
C48		Same as C4		
C49		Same as C5		
C50		Same as C12		
C51		Same as C9		
C52		Same as C1		
C53		Same as C3		
C54	556-120-162	Capacitor,Fxd,Ceramic,0.1μF, ±20%, 25 VDC	56289	5C02310AX0250 B3
C55, C56		Same as C3		
C57	150-2002-331FGO	Capacitor,Fxd,Mca,330pF,±2%, 500 VDC	72136	DM15F331G0500 WV4CR
C58		Same as C5		
C59	150-2002-501FJO	Capacitor,Fxd,D.Mca,500pF, ±5%, 500 V	72136	DM15F501J0500 WV4CR
C60		Same as C57		
C62, C63		Same as C3		
C64	150-2002-680EGO	Capacitor,D.Mca,68pF,±2%, 500 VDC	72136	DM15E680G0500 WV4CR
C65	150-2002-241FGO	Capacitor,Fxd,D.Mca,240pF,±5%, 500 V	72136	DM15F241G0500 WV4CR
C66	150-2002-101FGO	Capacitor,Fxd,D.Mca,100pF,±2%, 500 V	72136	DM15F101G0500 WV4CR
C67		Same as C64		
CR1, CR2, CR3, CR4, CR5, CR6, CR7, CR8, CR9, CR10, CR11, CR12	556-118-046	Diode, Switching, Silicon,40 PIV	93332	IN251
J1, J2	556-024-272	Jack, Phono	83330	1233
J3-1, J3-2, J3-3, J3-4, J3-5, J3-6	556-146-440	Post,PIN,PC,0.040 IN.DIA by 0.082 IN.LG SS Hard Gold Plate	71279	2971-2
L1	156-7002-022	Inductor,Fxd,5.6μH,±10%,0.640Ω, 710 MA,0.17D, Shielded	78526	DINK-5.6
L2	156-7002-041	Inductor,Fxd,220μH,±5%,4.10Ω, 280 MA,0.17D, Shielded	78526	DINK-220
L3		Same as L1		
L4		Same as L2		
L5	156-7002-037	Inductor,Fxd,100μH,±5%,2.60Ω, 345 MA,0.17D, Shielded	78526	DINK-100
L6		Same as L1		
L7		Same as L2		
L8		Same as L5		
L9		Same as L1		
L10		Same as L2		
L11		Same as L5		
L12		Same as L1		
L13		Same as L2		
L14		Same as L5		
L15		Same as L1		
L16		Same as L2		
L17		Same as L5		

LOG/LIN ASSEMBLY A3 A4 (Con't)

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
L18		Same as L1		
L19		Same as L5		
L20	156-7002-025	Inductor,Fxd,10μH,±10%,1.40Ω, 480 MA,0.17D, Shielded	78526	DINK-10
L21, L22, L23		Same as L2		
MC1	153-7018-001	Integr.Circuit,25Deg.Cat Ambient Temp,14 Lead Dual In-Line Pkg	86684	CA3030
Q1, Q2, Q3, Q4, Q5, Q6, Q7	556-146-251	Transistor, NPN	INSTD	2N3563
Q8	556-146-675	Transistor	INSTD	2N3641
R1	151-1002-391J	Resistor,Fxd,Comp,39KΩ, ±5%, 1/4 W	01121	CB3935
R2	151-1002-752J	Resistor,Fxd,Comp,7500Ω,±5%, 1/4 W	01121	CB7525
R3	151-1002-331J	Resistor,Fxd,Comp,330Ω, ±5%, 1/4 W	01121	CB3315
R4	151-1002-512J	Resistor,Fxd,Comp,5100Ω, ±5%, 1/4 W	01121	CB5125
R5		Not Used		
R6	151-1002-561J	Resistor,Fxd,Comp,560Ω,±5%, 1/4 W	01121	CB5615
R7		Same as R1		
R8		Same as R2		
R9		Same as R4		
R10	151-1002-390J	Resistor,Fxd,Comp,39Ω, ±5%, 1/4 W	01121	CB3905
R12		Same as R3		
R13	151-1002-102J	Resistor,Fxd,Comp,1KΩ,±5%, 1/4 W	01121	CB1025
R14		Same as R1		
R15		Same as R4		
R16		Same as R10		
R17		Same as R6		
R18		Same as R2		
R19		Same as R3		
R20		Same as R1		
R21		Same as R2		
R22		Same as R3		
R24		Same as R10		
R25		Same as R6		
R26		Same as R1		
R27		Same as R4		
R29	151-1002-621J	Resistor,Fxd,Comp,620Ω, ±5%, 1/4 W	01121	CB6215
R30		Same as R2		
R31		Same as R3		
R32	151-1002-272J	Resistor,Fxd,Comp,2700Ω, ±5%, 1/4 W	01121	CB2725
R33	151-1002-103J	Resistor,Fxd,Comp,10KΩ, ±5%, 1/4 W	01121	CB1035
R34		Same as R1		
R35		Same as R4		
R36		Same as R28		
R37		Same as R29		
R38		Same as R3		
R39		Same as R33		
R40		Same as R1		
R41		Same as R4		
R42		Same as R2		
R43		Same as R10		
R44		Same as R29		
R45		Same as R3		
R46		Same as R33		
R47	556-056-124	Resistor,Var,MiniatTrim,PC Perp Mtg,1KΩ, ±20%,1/4 W	11236	XHT201-2/1K, 20%
R48	151-1002-332J	Resistor,Fxd,Comp,3300Ω, ±5%, 1/4 W	01121	CB3325
R49, R50		Same as R4		

LOG/LIN ASSEMBLY A3A4 (Con't)

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
R51		Same as R1		
R52		Same as R4		
R53		Same as R2		
R54	151-1002-201J	Resistor,Fxd,Comp,200Ω, ±5%, 1/4 W	01121	CB2015
R55	151-1002-101J	Resistor,Fxd,Comp,100Ω, ±5%, 1/4 W	01121	CB1015
R56, R57, R58	151-1002-202J	Resistor,Fxd,Comp,2KΩ, ±5%, 1/4 W	01121	CB2025
R59	556-056-125	Resistor,Var,MiniatTrim,PC Perp, Mtg,10K, ±20%, 1/4 W	11236	VHT201-2/10K, 20%
R60		Same as R4		
R61, R62	151-1002-821J	Resistor,Fxd,Comp,820Ω, ±5%, 1/4 W	01121	CB8215
R63, R64 R65		Same as R33		
R66		Same as R4		
R67		Same as R10		

PULLED OSCILLATOR ASSEMBLY A4

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
C1	132-0315-001	Capacitor, Var.		
C2	150-0008-008	Capacitor,Var,Ceramic,Mini, 9-35pF,N650 PC BD Mtg	72982	538-011D9-35
C3	556-060-146	Capacitor,CeramicDisc,0.01μF, +60 -40%, 250V	71590	DA140-172B
C4	150-2002-501FGO	Capacitor,Fxd,D.Mca,500pF, ±2% 500 V	72136	DM15F501G0500 WV4CR
C5		Same as C2		
C6	150-5001-350DS	Capacitor,Fxd,Elect,35μF,+75-10%,15VDC,Insul	56289	TE-1159
C7		Same as C3		
FL1	556-146-774	Filter,Feed-thru,5KpF,200WVDC, 10A Max,W/Nut & Lkwshr	72982	1270-016/Nut & Lkwshr
J1	168-4035-001	Connector,Coax,Blkhd Jack, Conhex Series,50Ω,Snap-on	98291	51-043-0000
L1	132-0425-001	Coil		
Q1	556-146-923	Transistor	07263	2N4917
R1	151-1002-622J	Resistor,Fxd,Comp,6200Ω, ±5%, 1/4 W	01121	CB6225
R2	151-1002-102J	Resistor,Fxd,Comp,1KΩ, ±5%, 1/4 W	01121	CB1025
R3, R4	151-1002-101J	Resistor,Fxd,Comp,100Ω, ±5%, 1/4 W	01121	CB1015
R5	151-1002-470J	Resistor,Fxd,Comp,47Ω, ±5%, 1/4 W	01121	CB4705
T1	132-0308-001	Transformer, T1		
Y1	155-0006-001	Crystal,RS-50Ω,Max,Drive-2MW Max,Stability at RT±0.002%, Co-7-10pF,Freq 17.000 MHz, ±0.005%	88407	70AX W/HC-6/U Holder

SHAPING ASSEMBLY A5 (Con't)

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
C1	150-5008-003	Capacitor,Fxd,Electrolytic Tantalex,10μF,±20%, 20WVDC,Insul.	56289	150D106X0020B2
C2	556-120-162	Capacitor,Fxd,Ceramic,0.1μF, ±20%, 25VDC	56289	5C02310AX0250B3
C3	556-060-146	CeramicDisc,0.01μF,+60 -40%, 250 V	71590	DA140-172B
C4		Same as C2		

SHAPING ASSEMBLY A5 (Con't)

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
C5	150-2002-471FJO	Capacitor,Fxd,Mca,470pF, ±5%, 500 VDC	72136	DM15F471J0500 WV4CR
C6		Same as C3		
C7		Same as C2		
C8	150-2002-201FJO	Capacitor,Fxd,DMca,200pF, ±5%, 500V	72136	DM15F201J0500 WV4CR
C9		Same as C2		
C10	556-060-046	Capacitor,Fxd,Ceramic,0.001µF, ±10% 1K VDCW	71590	DD-102
C12	556-146-921	Capacitor,Fxd,MetPlasticFilm, Min,0.10µF,±10%,250 VDCW	25088	B32231-A3104-K
C13, C14	556-120-160	Capacitor,Fxd,Ceramic,0.47µF, ±20%, 25 VDC	56289	5C11
C15		Same as C12		
C19	150-2002-501FGO	Capacitor,Fxd,DMca,500pF, ±2%,500 V	72136	DM15F501G0500 WV4CR
C20	150-2002-301FJO	Capacitor,Fxd,DMca,300pF, ±5%, 500 V	72136	DM15F301J0500 WV4CR
C21		Same as C2	07263	
CR1 thru CR20	556-146-880	Diode,Switching,Silicon, 25WIV,4.0NS,Recovery		FDH-666
MC1	153-7023-001	Integ.Ckt,DualSchmittTrigger/ Triple Differential Ampli-fier,±1.0%, VDC	04713	MC1035
MC2	153-7021-001	Integ.Ckt,Dual,R-S Flip/flop, ±1.0% VDC	04713	MC1014
MC3	153-7022-301	Integ.Ckt,Triple 3-Input Gates,±1.0% VDC	04713	MC1007
Q1	153-3009-001	Transistor,Diff.Planar,NPN Sili-con,20VC,Max 500 MW, to 106 Case	INSTD	2N5133
Q2	153-3024 001	Transistor	INSTD	2N5139
Q3	153-0001-001	Transistor,Dual,Darlington Amplifier	INSTD	2N5306
Q4		Same as Q2		
Q5	556-146-989	Transistor,Silicon	INSTD	2N3904
Q6		Same as Q2		
Q7		Same as Q3		
Q8		Same as Q1		
Q9		Same as Q2		
Q10, Q11	153-3023-001	Transistor,PNP,Diff,Silicon Planar,150 V	07263	2N4889
Q12	556-147-196	Transistor,PNP,HV,Silicon Epitax Annilar	04713	MM4002
R1	151-1002-123J	Resistor,Fxd,Comp,12KΩ, ±5%, 1/4 W	01121	CB1235
R2	556-056-125	Resistor,Var,MiniatTrim,PC Perp Mtg,10K ±20%,1/4 W	11236	XHT201-2/10K, 20%
R3	151-1002-153J	Resistor,Fxd,Comp,15KΩ, ±5%, 1/4 W	01121	CB1535
R4	151-1002-302J	Resistor,Fxd,Comp,3KΩ, ±5%, 1/4 W	01121	CB3025
R5	151-1002-122J	Resistor,Fxd,Comp,1200Ω, ±5%, 1/4 W	01121	CB1225
R6		Same as R4		
R7		Same as R1		
R8		Same as R4		
R9	151-1002-102J	Resistor,Fxd,Comp,1KΩ, ±5%, 1/4 W	01121	CB1025
R10	151-1002-512J	Resistor,Fxd,Comp,5100Ω, ±5%, 1/4 W	01121	CB5125
R11	556-146-541	Resistor,Var,MiniatTrim,PC Perp Mtg.5K,±20%,1/4 W	11236	XHT201-2/5K,20%
R12		Same as R4		
R13	151-1002-202J	Resistor,Fxd,Comp,2KΩ, ±5%, 1/4 W	01120	CB2025
R14		Same as R5		
R15	151-1002-303J	Resistor,Fxd,Comp,30KΩ, ±5%, 1/4 W	01120	CB2025
R16		Same as R9		
R17	151-1003-104J	Resistor,Fxd,Comp,100KΩ, ±5%, 1/2 W	01120	EB1045
R18	151-1002-184J	Resistor,Fxd,Comp,180KΩ, ±5%, 1/4 W	01120	CB1845
R19		Same as R10		

SHAPING ASSEMBLY A5

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
R20	151-1002-103J	Resistor,Fxd,Comp,10K , ±5%, 1/4 W	01120	CB1035
R21	151-1002-433J	Resistor,Fxd,Comp,43KΩ, ±5%, 1/4 W	01120	CB4335
R22		Same as R13		
R23		Same as R11		
R24		Same as R3		
R25		Same as R13		
R26		Same as R5		
R27		Same as R1		
R28		Same as R10		
R29	151-1002-432J	Resistor,Fxd,Comp,4300Ω, ±5%, 1/4 W	01121	CB4325
R30	151-1002-362J	Resistor,Fxd,Comp,3600Ω, ±5%, 1/4 W	01121	CB3625
R31		Same as R9		
R32	151-1003-560J	Resistor,Fxd,Comp,56Ω, ±5%, 1/2 W	01121	EB5605
R33		Same as R5		
R34	151-1002-183J	Resistor,Fxd,Comp,18KΩ, ±5%, 1/4 W	01120	CB1835
R35	151-1002-203J	Resistor,Fxd,Comp,20KΩ, ±5%,	01120	CB2035
R36		Same as R34		
R37	151-1002-152J	Resistor,Fxd,Comp,1500Ω, ±5%, 1/4 W	01121	CB1525
R38, R39	151-1002-100J	Resistor,Fxd,Comp,10Ω, ±5%, 1/4 W	01121	CB1005
R40	151-1002 241J	Resistor,Fxd,Comp,240Ω, ±5%, 1/4 W	01121	CB2415
R41	151-1002 332J	Resistor,Fxd,Comp,3300Ω, ±5%, 1/4 W	01121	CB3325
R42	151-2024-1001F	Resistor,Fxd,MoldedMetFilm, 1K, ±1%,1/4W,TempCoef.70 PPM/Deg C	MILPN	60C1001F
R43	151-0045-004	Resistor,Var,Pot,Trimming,Cube SideAdjust,50K,±20%, 1/4 W	02111	53-2-1-503
R44		Same as R35		
R45		Same as R42		
R46		Same as R43		
R47	151-1002-243J	Resistor,Fxd,Comp,24KΩ, ±5%, 1/4 W	01121	CB2435
R48		Same as R42		
R49	151-0045-006	Pot,Trimming,CubeSideAdjust, 20K,1/2 W,±20%	02111	53-2-1-203
R50		Same as R15		
R51	151-2024-2001F	Resistor,Fxd,MoldedMetFilm, 2K,±1%,1/4W,TempCoef, 70 PPM/Deg.C	MILPN	RN60C2001F
R52		Same as R49		
R53		Same as R1		
R54		Same as R49		
R55	151-0045-009	Resistor,		
R56		Same as R20		
R57		Same as R51		
R58		Same as R55		
R59	151-1002-392J	Resistor,Fxd,Comp,3.9KΩ,±5%, 1/4 W	01121	CB3925
R60		Same as R51		
R61	151-0045-005	Pot,Trimming,CubeSideAdjust, 5K,±20%,1/2 W	02111	53-2-1-502
R62		Same as R41		
R63		Same as R51		
R64		Same as R61		
R65		Same as R13		
R66		Same as R51		
R67		Same as R61		
R68	151-1002-911J	Resistor,Fxd,Comp,910Ω, ±5%, 1/2 W	01121	EB9115
R69		Same as R42		
R70	151-0045-003	Pot,Trimming,CubeSideAdjust, 2K,±20%, 1/2 W	02111	53-2-1-2002
R71	151-1002-621J	Resistor,Fxd,Comp,620Ω, ±5%, 1/4 W	01121	CB6215

SHAPING ASSEMBLY A5 (Con't)

CIRCUIT REFERENCE	SINGER PART NO.	DESCRIPTION	TRUE MFR. FSC NO.	TRUE MFR. PART NO.
R72	151-1003-391J	Resistor,Fxd,Comp,390Ω,±5%, 1/2 W	01121	EB3915
R73	151-2024-1002F	Resistor,Fxd,MoldedMetFilm, 10K,±1%,1/4 W,TempCoef, 70 PPM/Deg.C	MILPN	RN60C1002F
R74	151-1002-272J	Resistor,Fxd,Comp,2700Ω,±5%, 1/4 W	01121	CB2725
R75	151-2023-1002F	Resistor,Fxd,MoldedMetFilm, 10K,±1%,1/10W,TempCoef, 50 PPM/Deg.C	MILPN	RN55C1002F
R76		Same as R49		
R77		Same as R75		
R78		Same as R61		
R79	151-2023-1332F	Resistor,		
R80	151-1002-154J	Resistor,Fxd,Comp,150KΩ,±5%, 1/4 W	01121	CB1545
R81	151-0045 008	Resistor,Var. Pot,Trimming,Cube SideAdjust,500K,1/2W, ±20%	02111	53-2-1-504
R82	151-2023-2213F	Resistor,		
R83	151-1003-753J	Resistor,Fxd,Comp,75KΩ,±5%, 1/2 W	01121	EB7535
R84	151-1002-101J	Resistor,Fxd,Comp,100Ω,±5%, 1/4 W	01121	CB1015
R85	151-1003-512J	Resistor,Fxd,Comp,5100Ω,±5%, 1/2 W	01121	EB5125
R86	151-2023-341F	Resistor,		
R87	151-1004-182J	Resistor,Fxd,Comp,1800Ω,±5%, 1 W	01121	GB1825
R88	151-1004-332J	Resistor,Fxd,Comp,3300Ω,±5%, 1 W	01121	GB3325
R89	151-1002-300J	Resistor,Fxd,Comp,30Ω,±5%, 1/4 W	01121	CB3005 C
R90		Same as R9		

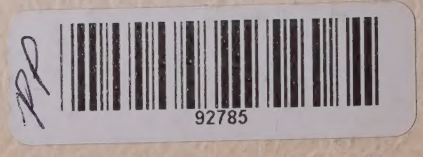
SHIPMENT DAMAGE CLAIM

The instrument should be tested as soon as it is received. If it fails to operate properly or is damaged in any way, a claim must be filed with the carrier. Have carrier agent inspect damage to instrument and packing crate and forward us a copy of his written report. You will then be advised of replacement or repair arrangements and disposition of the equipment. Please include model number, type number and serial number when referring to this instrument for any reason.

REPACKING FOR SHIPMENT

The instrument should be packed in the original carton. If unusable or not available, use a wooden box with approximately three inches of excelsior or other shock-absorbing material surrounding the instrument. If desired, packing services of a local transfer and storage company may be employed.

SINGER
INSTRUMENTATION


92785